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SCIENTIFIC AMERICAN SUPPLEMENT

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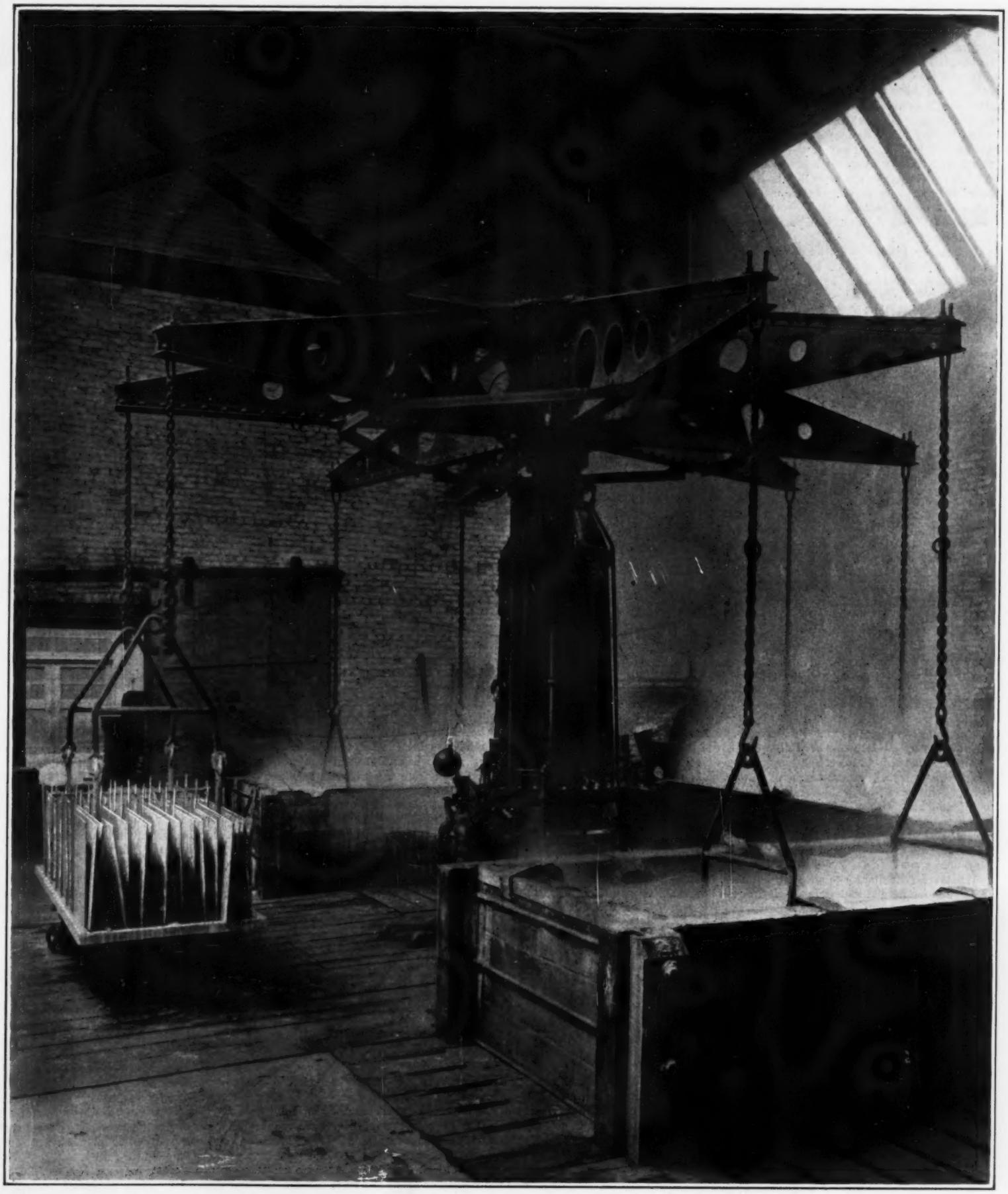

Crates suspended from radial arms are swung by rotation of a central column over pickling vats.

MODERN PICKLING MACHINES.—[See page 404.]

Shall We Have Bridges or Tunnels?*

Past Experience Furnishes the Answer

By G. F. Kunz

In dealing with the tunnels in operation at the present day in connection with the great railroad terminals of New York city it was observed[1] that in no case was provision made for any other use of the tunnel than for railway traffic. "The great volume of traffic that does not and cannot use the railways must still cross the Hudson by ferry alone. This state of things cannot continue long, now that railroad tunnels have been successfully constructed and the method is shown to be so possible."

In the present article the writer will briefly review some of the schemes proposed for traffic tunnels under the rivers, and also for subway routes to connect them with each other and with the principal thoroughfares.

In the first place, we may note that this latter idea has already been carried out on the New Jersey side of the Hudson, in the subway of the McAdoo system already described, connecting the several railway termini and the river tunnels. Something of the same kind will surely be needed on the Manhattan side—a subway near and parallel to the river. But of this, more will be said later.

The congestion of the business streets and of the waterfront by vehicles of all kinds carrying freight has reached a point where it has become very serious, and threatens to restrict the further development of commerce at this port. Besides the railway terminals, some of the most important steamship lines now dock on the New Jersey side, and hence vast amounts of freight must be taken over the ferries both ways, and handled on both sides of the river to load and unload. The cost and the delays involved by these conditions are enormous, the former alone rising into many millions annually.

To meet this grave necessity for relief there has been proposed by Mr. C. Wilgus—a leading engineer connected with the New York Central Railroad system—and laid before the Public Service Commission,[2] a plan consisting essentially of a subway road for the carriage and delivery of freight along the waterfront. It is proposed to have branches beneath the main business streets, and a belt line under South and West Streets, the latter connecting with the New York Central yards at West Sixtieth Street and with tunnels under the Hudson and East Rivers, and so with the opposite water-front on each. The freight is to be carried on these roads in cars of standard gage, which thus can run directly into the yards or stations of any connecting railroad for reception or delivery. There will also be tracks leading out on the principal steamship piers. The larger transfers of freight are to be made at points distant from the crowded parts of the city; and the subways are planned on a scale to handle nine tenths of the freight that is now slowly and laboriously carted through the streets. The scheme also contemplates an elevated railway for passengers in the space over the belt tracks, in the river-front streets relieved of their present congestion. The project is a most elaborate and extensive one, but is very carefully and skillfully wrought out.

Another plan is to construct a passenger subway parallel to the river fronts, connecting with new tunnels at several points, as well as with the railroad tunnels already built, and also with the existing subway lines at the various stations. This would be a reproduction on a greater scale—and with transverse branches to connect with the present subways—of the McAdoo line on the New Jersey side.

Whatever system shall be adopted, however, for passenger and freight distribution in the city, we are brought back to the problem of tunnels beneath the Hudson; and here some interesting and important questions arise as to the manner of their construction.

All the tunnels before described have been circular tubes, excavated essentially by a process of simple boring. Indeed, it is said that Mr. Greathead, the inventor of the "shield" method that bears his name and has been used in almost all the work herein described, derived his idea of the iron "shield" for tunnel construction from the method by which the boring mollusk, Teredo (commonly known as ship-worm) makes its tubular burrowing in timber, protected by its small cylindrical shell in front, and lining the tube as it proceeds, with a calcareous coating.

This form of tunnel has some disadvantages, however. If enlarged sufficiently to take two tracks, or roadways, much waste space remains above and below them. The Pennsylvania tunnels are 23 feet in diameter, and are lined with 2½ feet of concrete, leaving 18 feet of clear width. A slight enlargement would allow room for two roadways for vehicles, and a footpath. Such a tunnel could be built, according to Mr. Davies, the engineer who constructed the East River tunnels for the Pennsylvania road, at a cost not exceeding $3,000,000 a mile—about the length necessary for the Hudson. But a further enlargement would afford much greater advantage p oportionately in regard to space. The latest proposition is one made by Messrs. Jacobs and Davies, for a Hudson tunnel of 31 feet diameter outside and 28 feet 9 inches within, to accommodate four roadways, two above and two below, with a footpath on each side of the upper level. The tube is divided at its middle by a horizontal partition of concrete; above this are two roadways for slow traffic—trucks, vans, etc.—12 feet high and 9 feet wide; and below it are two roadways for rapid vehicles—automobiles, etc.—9 feet high and 8 feet wide. The concrete lining, somewhat as in the Pennsylvania Railroad tubes, is carried up vertically to the partition; above this is a footway in the semi-arch on either side, of 4 feet 6 inches width, alongside of the truckway; beneath this is a passage or gallery in the concrete filling, for pipes, electric wires, etc.; and provision is made for air-passages and drainage in like manner. The whole is a most complete and systematic plan, and seems admirably adapted to meet the requirements of such a tunnel, with remarkable economy of space.

Another tunnel has been built, however, in a wholly different manner—that beneath the Harlem River at One Hundred and Forty-fifth Street, for the Rapid Transit Subway. This was constructed by Mr. Duncan D. McBean, and he has proposed to the Public Service Commission to use the same method for tunneling the Hudson and East Rivers, with certain advantages of construction over the tube form, and at less expense. The Harlem River tunnel was built without any mishap, and has served its purpose perfectly. Can the same process be applied to the Hudson?

The McBean method is essentially the following: A wide trench is dredged in the river-bed to about half the depth of the tunnel, and walled off from the water with timber casing. The upper half of the tunnel is built outside, in semi-cylindrical segments; and these are lowered into place one by one. The ends are closed by temporary partitions so as to make the upper half serve as a work-chamber, in which compressed air can be used, while beneath, the lower half of the tunnel is excavated, and then lined with concrete. Later, concrete and filling are added externally, the trench filled up and the cross-partitions and outside casing removed. In this method, the tube is not of necessity a cylinder; and two or several roadways may be built side by side, without increasing the height; while two side-walls only are necessary for the whole to withstand the external pressure—the several roadways being separated simply by partitions or bracing. The whole rests upon a strong foundation of piling, driven from the trench to rock.

This last statement carries with it the entire case, as regards the Hudson. The plan worked well in the Harlem River, where the rock lies at very moderate depths; but it is needless to repeat here what has been already emphasized in this article—as to both piers for bridges and pile-work for tunnels—that the depth to rock in the Hudson is prohibitive for either.

In Mr. McBean's proposal to the Commission, after describing the advantages of his method and its successful application to the Harlem tunnel, he offers to construct several tunnels of 100 feet wide, giving two double roadways—one for trains and one for automobiles—four car-tracks, and a footway, all side by side, with an interior height of 18 feet. The cost for any of these tunnels, he specifies as $1,000 per foot of length.

After reading this account, and examining the careful drawings that illustrate the plan, it is very disappointing to recognize the fatal difficulty in the way. In a published letter to the Mayor of New York (September 19, 1910), as to a proposed new tunnel under the Harlem River, Mr. McBean says that in his method "the pile foundation is an integral part of the structure (which cannot be omitted in soft ground), thus insuring the integrity and permanency of the foundations at every point." (P. 5.)

Still another method has been used, at Detroit, Mich. In this, which is known as the Wilgus, or Trench method, some of the features of the last are united with the tube form. A trench is dredged, to the full depth of the tunnel, and into this are lowered sections of iron tube which are joined on to each other to form a roadway or track-way. Several such tubes may be laid nearly side by side, with bracing between; and when finished, the whole lower part of the trench is filled with concrete, encasing and embedding the tubes, beneath, around, and above. The concrete is laid under water, through pipes, under the supervision of divers. This method gives a very solid concrete structure, enclosing the iron tube-ways. All these are on one level, as in the McBean system. The Wilgus method has been proposed for the new four-track subway tunnel under the Harlem River, but we are not aware that it has been suggested for the Hudson. It is possible that such a firm concrete structure might dispense with the pile foundation. In calling for proposals for the new Harlem tunnel, the Public Service Commission have not positively required this feature in a structure of the Wilgus type, but have left it optional, apparently with the view that, as in the Pennsylvania Railroad tunnels, a foundation is not essential to stability. In that case this method might be applicable to the Hudson; but the dredging of a wide trench to the necessary depth, with all the crib-work, etc., requisite, would be a matter of great difficulty and great cost, in a river so broad and deep.

One other suggestion may be noted here, as bearing on the Hudson problem. Mr. Alexander E. Dandridge, in a recent letter, has taken the ground that engineers in general have erred in assuming that they must accept whatever kind of material Nature has provided in a river-bed, and penetrate it as best they can. He advocates instead the formation of an artificial bed, through which a tunnel can afterwards be bored. His plan is to use crushed traprock, mingled with a suitable proportion of stiff clay to give it firmness and coherence. This he would dump from scows into the river for a space several hundred feet wide and bring it up to near the surface, from the shore outward for a thousand feet. The weight of this load would press the lower portion of the mass into a very compact condition. Then the upper part would be dredged off, leaving a water depth of say fifty feet, and the material dumped onward for another thousand feet, and the same process repeated until a basement of this kind had been laid across the whole distance. Then, through this submerged causeway, as it might be called, the tunnel would be made by boring, with a firm stiff bed and wall instead of the loose river silt.

This suggestion is ingenious, and seems at first sight very feasible. The question would be, however, as to such a dense mass retaining its position amid and upon the silt. A causeway or embankment built across swampy ground is liable to settle, sometimes even causing the ground to rise in ridges parallel to it, at considerable distances. On land, where the road or track is on the top of the causeway, repairs and addition are easy; but in a tunnel enclosed within such a causeway, and beneath a deep river, settling would be a very serious matter. This question is probably impossible of determination save by actual experiment, and after considerable time; and this uncertainty seems to bar the way to Mr. Dandridge's well-reasoned scheme being attempted.

The tube-method, however, has already been used with apparently complete success, in the river bottom as it is; and if no tendency appears to settling or other weakness in the railroad tunnels, with their extremely heavy and rapidly-moving trains, none need be feared for tunnels used for ordinary traffic and for the slow carriage of freight. The objection as to waste of space in a circular tube has been eliminated in the Jacobs-Davies plan of a two-story tunnel, above described; and there seems no reason to doubt that ere very long the Hudson River may be traversed by several tunnels constructed on some such plan. If these should then be combined with a freight-subway in the city, such as the Wilgus system proposed, or something similar, and with the existing subway for passenger travel, a very comprehensive scheme would be developed, for the relief of the congestion that has now become so serious, and for the further development of the metropolis of America.

London is now traversed by a great connected system of subways and river tunnels, amounting to a total of many miles, and now approaching completion after years of experiment and construction. New York will surely be similarly provided in the near future.

The first Thames tunnel, between Rotherhithe and Wapping, was planned by Marc Isambard Brunel. A shield of timber having several independent sections was used. The work was begun in 1825 and completed in 1843, the cost being about £1,300 per linear yard. In part this tunnel was carried through almost liquid mud.

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* Reprinted from Appendix B of the Eighteenth Annual Report of the American Science and Historic Preservation Society.

[1] SCIENTIFIC AMERICAN SUPPLEMENT No. 1979, page 370.

[2] SCIENTIFIC AMERICAN, vol. xcix., No. 23, December 5, 1908, page 413.

The Blackwall tunnel, for which Sir Alexander Binnie was engineer, is 3,116 feet in length by 24¼ feet interior diameter. In this case the passage was made through clay and about 400 feet of water-saturated gravel. Operations were begun here in 1892, the work being finished in 1897. The third and largest of these Thames tunnels, that known as the Rotherhithe tunnel, has a cross-section larger than that of any other similar construction. Maurice Fitzmaurice was the engineer and designer of this tunnel, which was carried through sandy and shelly clay overlying a seam of limestone resting upon a stratum of pebbles and loamy sand; for 1,400 feet it runs directly under the river bed. Four years were required for its completion, from 1904 to 1908.

Of the two later constructions, the Blackwall tunnel measured 4,470 feet from portal to portal (6,200 feet between grade points), the tube has an external diameter of 27 feet and an internal diameter of 25 feet 4 inches; through it runs a roadway 16 feet wide and 17 feet 7½ inches high at center, and two foot-ways each 3 feet 1½ inches in width. The corresponding dimensions for the more recently built Rotherhithe tunnel are: length from portal to portal 5,200 feet (between grade points 6,883 feet); roadway 16 feet wide with a height at centre of 18 feet 6 inches; two footways each 4 feet 8½ inches wide. The number of vehicles that passed through this tunnel in 1911 was 896,629 and in 1912, 973,336; the volume of traffic through the Blackwall tunnel is stated to be nearly as large.[3]

In some of the tunnel plans it has been proposed to do away with the difficulty of approaches, which involve a great expenditure of space, by a system of elevators. The tunnel would terminate at the actual river-front, in a spacious chamber, in which would be installed elevators large enough to take vehicles of any size up and down between the tunnel and the street-level. Something of this kind wil undoubtedly be a feature of the new tunnels for automobiles, carriages and freight.

That it is perfectly practicable to construct a large tunnel at a relatively small outlay is shown by estimates submitted for such a tunnel, to be built on the McBean method. Here elevators placed at the bulkhead line at each termination would lower and raise cars, vehicles and pedestrians, to and from the tunnel. The entire width of the whole structure would, as we have already stated, be about 100 feet, and the total cost of building such a tunnel between Manhattan Island and the New Jersey shore would be about $5,000,000.

The great difference in the expense of maintenance must also be considered in comparing the total expenditure for a bridge with that entailed by the building of a tunnel. The up-keep of a cement-like tunnel would be almost nominal, whereas the cost of a bridge, with its tendency to rust, the cracking of bolts, etc., is enormous. One single item of expense for the Queensboro Bridge, the painting of the structure, amounted to $33,000.

The cost of building a bridge would be from ten to twenty times as great as that of tunneling the river; and as we can now estimate closely both the time and the expense required for the construction of a tunnel, we can safely assert that within a comparatively short period there could be three or four large enough for traffic, special ones for automobiles, and also others for railroads. A notable advantage would be that these various tunnels could be located at a number of different points along the river, at Fifty-ninth, Eighty-sixth, Ninety-sixth, One Hundred Tenth, One Hundred Thirtieth, One Hundred Thirty-seventh, One Hundred Fifty-seventh, and One Hundred Eighty-first Streets, to connect with the main thoroughfares and subways—thus satisfying the requirements of those who have advocated these different sites for the construction of a bridge, and who have been forced to agree upon a single site. There is little doubt that we could have a double tunnel at each and every one of these streets for the cost of one bridge.

In making any of these improvements, however, one thing should always be borne in mind, the necessity of preserving intact, as far as possible, the beauties of Riverside Park, one of the great ornaments of our city. Hence the laying of surface tracks and the establishment of extensive freight-yards within the boundaries of the park should be avoided. All the requirements of the railroad can be satisfied and the park preserved by placing the tracks under cover, and to this there can be no objection. The successful operation of our subway transporting under comfortable conditions 1,200,000 passengers daily, renders any objection to underground means of transit certainly unreasonable, especially as all trains within the greater metropolis will certainly be and should be operated by electricity An important consideration in favor of this plan is the fact that it would remove all danger of injury from passing trains to anyone not immediately connected with the operation of the railroad, as only employees of the railroad would be permitted to have access to the subway; moreover this provision would also do away with the petty thieving now possible. An ideal plan, and a perfectly feasible one, would be to lay the main freight tracks on the Jersey side of the river, where within a comparatively short distance of the river front land can be acquired at a very reasonable cost. Tunnels could then be built across the river at points in a line with St. John's Park, Thirtieth, Street, Fifty-ninth Street, Seventy-second Street, and One Hundred Thirtieth Street, conveying the freight directly to these distributing points, the main yards to be on the Jersey side. For a two-track road running from Fifty-ninth Street to Two Hundred Tenth Street, the New York Central Railroad now occupies about thirty acres of ground or forty-five acres for a three-track and sixty acres for a four-track road. And they are much hampered for lack of proper freight yard facilities. It would not cost much to purchase an area of 3,000 or 4,000 acres in the Jersey meadows. This, to say nothing of the obligation which ought to rest upon any truly representative corporation, to respect and preserve one of the greatest heritages of New York city, the banks of the noble and beautiful Hudson.

In the report of the New York State Bridge and Tunnel Commission submitted to the Legislature in April, 1913, the commissioners favor the construction of tunnels instead of a bridge. This preference is based on the drawbacks of the proposed bridge apparent from a consideration of a tentative plan proposed by Boller, Hodge and Baird, consultant engineers to the Commission. As the opinion prevailed that the neighborhood of Fifty-seventh Street would be the best point for the New York end of the proposed bridge the estimated length of the main structure and its approaches refer to a bridge constructed there. The entire length, including approaches, from Ninth Avenue and Fifty-seventh Street, Manhattan, to the Boulevard in Weehawken would be 8,330 feet, and the great central span would measure 2,730 feet in length between pier-head lines and 2,880 from one tower center to the other. Accommodations would be afforded for eight lines of rapid transit trains, as well as for two driveways, each thirty-six feet wide, so that four vehicles could travel abreast, and also for two footways, each eight feet in width. The supporting towers would rise to the unexampled height of 745 feet from bed rock, but 239 feet less than the height of the Eiffel Tower. In view of the altogether exceptional character of the structure, the eventual cost would probably greatly exceed the original estimates, and hence even the large sum of $42,000,000 given by expert engineers may be much too low. There is, therefore, every reason to commend the present preference of the commission for tunnels, two of which would cost but $11,000,000, and the changed attitude of the members in this respect from that assumed a few years since proves that they were open to conviction and impartially anxious to recommend the course best calculated to further public interests and welfare.

Not only would large tunnels of this type aid most powerfully in the development of the commercial interests of lower Manhattan, at the same time helping largely to relieve the present congestion, daily growing worse, but it has been figured that they might bring in a very satisfactory percentage on the money invested in them. Putting the annual interest charges on capital at $550,000 and the yearly cost of maintenance at $90,000, we have $640,000 to be provided for. Should 5,000,000 vehicles use the tunnels in the course of the year, as is indicated by the volume of ferry traffic, and should the average toll be received as is now collected by the ferries (about 24 cents per vehicle) there would be an annual revenue from this source of $1,200,000, showing a profit about equal to the amount of the interest charges.[4]

The legal status of the land beneath the Hudson has been partially defined in a recent decision by Supreme Court Justice Arthur S. Tompkins. He was called upon to determine whether the New York Central Railroad Company could condemn land under water near Peekskill which the company wished to fill up so as to straighten out their tracks and enlarge the road here in establishing the projected four-track system to Peekskill. Several private owners laid claim to this sub-aqueous land under a charter granted June 17, 1697, by King William III to Stephanus Van Cortlandt, and it was also contended by the Attorney-General that as the State held the land under water in trust for the people, such lands could not be acquired from it by a corporation. However, Judge Tompkins decided against this latter contention, holding that where there was proof that the land was necessary for railroad purposes it might be acquired for this use, noting that in case of an attempt to thus acquire all the lands under the river—a contingency suggested in the Attorney-General's brief—the claim could be successfully resisted with the argument that no legitimate railroad use could require the entire river bed of the Hudson or any other river.

A comprehensive plan for the improvement of the facilities for freight handling on the west front of New York city has been proposed by D. C. Willoughby, of Boston, and submitted to the consideration of the Board of Estimate. Although the requisite capital, estimated at $85,000,000, would be provided from private sources, the title to the subway, warehouses and and tunnels projected, would be from the outset vested in the city, only the equipment being regarded as the company's property; the latter also would be accorded a twenty-five years' franchise, with one renewal for a like period.

The plan provides for the construction of a six-track subway, running beneath a marginal way along the river front from Cortlandt Street to Twenty-third Street, two of the tracks being brought into connection at this point, by means of a cross-over, with the New York Central's tracks. The other four tracks would connect with a freight tunnel to be carried beneath the North River at about Twenty-third Street, passing out into a freight classification yard in New Jersey. Above the marginal way, on the New York side of the river, immense warehouses would be erected, one for every four blocks, in which space could be rented by merchants in the neighborhood for the reception of freight consigned to them. It would thus be possible, after proper classification of the freight in the New Jersey yard, to transmit by mechanical means the lots consigned to each merchant directly to the warehouse wherein he had reserved space, obviating the necessity of long cartage from a distant point to the merchant's place of business. There would also be a small classification yard in Manhattan for the distribution of fractional parts of a carload. Should this plan be put in operation it is estimated that as many as 2,642 cars could be loaded or unloaded simultaneously. Of the $85,000,000 to be expended in all, the Manhattan subway would cost $16,486,000, and the warehouses, the subsidiary yards, etc., in Manhattan, $25,000,000, making a total of over $40,000,000 to be expended within that borough.

In St. Louis it has been found practicable to run complete freight trains through a tunnel into the basement of the building occupied by a great hardware firm. The cars, loaded with consignments from the manufacturers, are here divided into so many different groups and labeled to the different firms to which the hardware is to be shipped, whether a single carload, five carloads, or ten carloads, no unloading and reloading being requisite.

A proposition for a four-tube, or a six-tube tunnel under the East River has been submitted by Duncan D. McBean to the consideration of the Public Service Commission, with the claim that a four-tube tunnel of this type could be built for but 50 per cent more than the cost of one of the three two-tube tunnels to be constructed on the shield method as proposed by the Public Service Commission. Two of the four McBean tubes would constitute a roadway 39 feet in width and 15 feet 9 inches in height. A marked advantage over a tunnel built on the shield method would be a lesser depth, 65 feet beneath the river surface instead of 95 feet, thus considerably shortening the necessary approaches, which might be made to begin respectively at Broad Street, Manhattan, and Montague Street, Brooklyn. Should a six-tube tunnel of this type be constructed, Mr. McBean suggests that two of the tubes be used by the Interborough Broadway subway line and two by the Brooklyn Railway, leaving the present tunnel under the East River for the Seventh Avenue subway line.

A further extension of one or more of the traffic tunnels may also be considered, viz., that instead of terminating at or near the river-front, on the New Jersey side, it should be continued westward under the Palisade ridge, so that traffic of all kinds could pass through the hill and have access to roads in the open region beyond. This, it will be remembered, is the case already with the tunnel of the Pennsylvania Railroad, which emerges at some distance west of the Palisades. As with that one, there should be of course also a north and south connection near the river, for vehicles and freight; but a continuation beneath the ridge would open up large added possibilities.

As a recognition of the growing sentiment in favor of tunnels we may note that by chapter 189 of the Laws of 1913, the name of the New York Interstate Bridge Commission was changed to that of the New York State Bridge and Tunnel Commission.

A Lead-Sodium Alloy

METALLIC sodium hardens lead without changing its color. Two per cent of sodium will harden lead so that it will ring when struck; a larger amount causes it to become brittle. The lead-sodium alloy is sometimes used as a bearing metal. One of the bad features of the alloy is that it corrodes rapidly in damp air or in contact with water.—*English Mechanic and World of Science.*

[3] To the New Jersey Interstate Bridge and Tunnel Commission, a Presentation in the Matter of Tunnels or Bridges for Highway Crossing of Hudson River, by Jacobs & Davies, Inc., Feb., 1913, p. 12.

[4] To the New Jersey Interstate Bridge and Tunnel Commission, a "Presentation in the Matter of Tunnels or Bridges for Highway Crossing of Hudson River," by Jacobs and Davis, Inc., February, 1913, pages 5, 6, 9.

Modern Pickling Machines

Halving Acid Consumption and Labor by Up-to-Date Design

By Frank C. Perkins

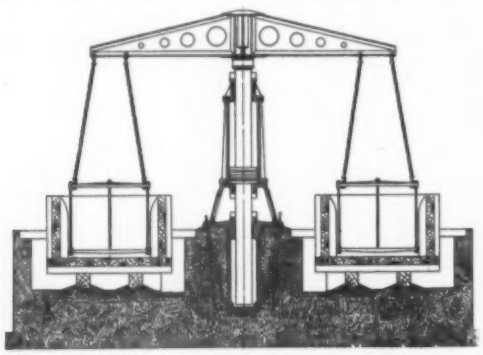
Our frontispiece and the photograph reproduced on this page show a modern pickling machine. Some details of the methods of supporting the machine and balancing the cylinder are shown in the line drawing.

As our readers know, in the iron, steel and metal industries generally, the hot-working of metals renders it necessary, after such treatment, to cleanse the material with acid, or, as the trade express it, "to pickle" them; for in such processes as enameling, plating, galvanizing, it is quite essential to have clean metal surfaces free from oxide.

Various machines have been brought into use for the purpose of handling the plates during the pickling operation. One such machine of modern make and great efficiency is that here illustrated. It is claimed that with this equipment material is pickled with one half the consumption of acid ordinarily required and with one half the labor consumed in most other processes of pickling.

Some of the features of the process which helps to secure these excellent results consist in an arrangement for moving the material through the acid with a predetermined velocity, and with a slight jarring motion. The effect of this method is to separate the sheets of metal long enough to allow the acid to enter between them, preventing the plates from sticking together.

The washing action of the acid is enhanced by the movement of the loose scale which scours the surface of the sheet. At the same time, the agitation of the acid prevents layers of different strength and density from forming. This is of supreme importance in pickling sheet metals, since otherwise there is apt to be a lack of uniformity in the thickness of the resulting plates.



Free-standing type of pickling machine, showing method of support in foundation and balancing compressed air cylinder.

As will be seen from our illustration, the machine consists of a number of horizontal arms radiating from a central plunger and carrying acid proof crates suspended by chains from the end of the arms. The plunger is lifted by steam pressure and descends by gravity. When the machine is to be lifted out of the vats, a control lever is pressed down. The crates then float in the steam over the pickling bath and can easily be turned into any desired position, such as over a new set of pickling vats. Another movement of the lever then lowers the crate into the vat, and the operation is automatically resumed. At first the machine was secured to the foundation by bolts. The corroding action of the acid however acted upon the nuts of the foundation bolts (and particularly in the machines of large size) the clearance produced caused the machine to vibrate, making it necessary to tighten the nuts from time to time. As will be seen in the line drawing, the machine here described has a downwardly projecting cylinder, which is imbedded in concrete, hence no foundation bolts are required and the machine requires practically no attention. It will be noticed that from this cylinder radiate ribs which offer a large surface to the concrete for adhesion. Besides giving stability to the machine this cylinder affords protection to the lower part of the piston rod.

Considerable economy in steam is secured by filling the bottom cylinder and the interior of the piston rod with compressed air, thus balancing the greater part of the dead weight of the machine, a small quantity of steam being used merely for lifting the loaded crates. The compressed air is never exhausted but is permanently retained in the cylinder. The smallest size compressor on the market will be of ample size to supply the air lost by leakage. The pickling machine shown in the last of our engravings has an overhead bearing fastened to a suitable part of the building, such as roof truss. The bending action caused by the loading of the radial arms is taken up in this case by the building, and the machine frame, being relieved of bending stresses, can be made lighter and cheaper.

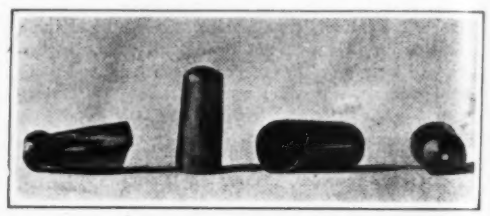
It is true that this brings with it the disadvantage that no overhead crane can pass by the machine, and that any movement of the building due to temperature changes, settling or otherwise, causes the overhead bearing and the steam cylinder with its piston to wear. For this reason the machine with overhead bearing is not very extensively used, as the type shown in our frontispiece and line drawing which is free from this drawback.

Pickling machine. The type here shown is steadied by a support fastened to the roof truss.

Metal Finger Guards as Safety Devices for Machine Operators*

The operation of machines for punching, stamping, and pressing metals is often attended by a great deal of personal danger. The operator becomes careless, or his attention is momentarily diverted, or he relies too implicitly upon the dexterity that comes with long experience and training; and the result is, that he loses a finger or a hand.

Presses and punches are of many different kinds, and the problem of safeguarding them is often extremely difficult. The best method of preventing accidents from the use of such machines consists in providing two operating handles, set some distance apart, and arranged so that the operator's hands must both be occupied, simultaneously, by the act of setting the machine in motion. Although this plan is the best of all, it cannot be applied with advantage, in every case; and when it is not practicable, other methods of safeguarding must be devised. For certain forms of machines, however, no guard yet devised is entirely satisfactory.



Metal Finger Guards.

Adequate protection may sometimes be afforded by the use of metal finger guards similar to those illustrated in the accompanying engraving, which shows three unused finger guards and one that was crushed while being worn by a machine operator. Guards of this kind are made in several sizes, to suit both men and women operators. The small hole seen in the engraving at the end of the guard at the right is drilled there to ventilate the space beyond the tip of the finger, and to facilitate the removal of the finger by preventing the formation of a partial vacuum in this space.

Finger guards are sometimes reinforced at the end, by making the tip considerably thicker than the main body of the guard, and this is the type shown in the engraving. The reinforced guard is distinctly preferable to the kind without reinforcement, on account of the greater resistance that the reinforced end offers.

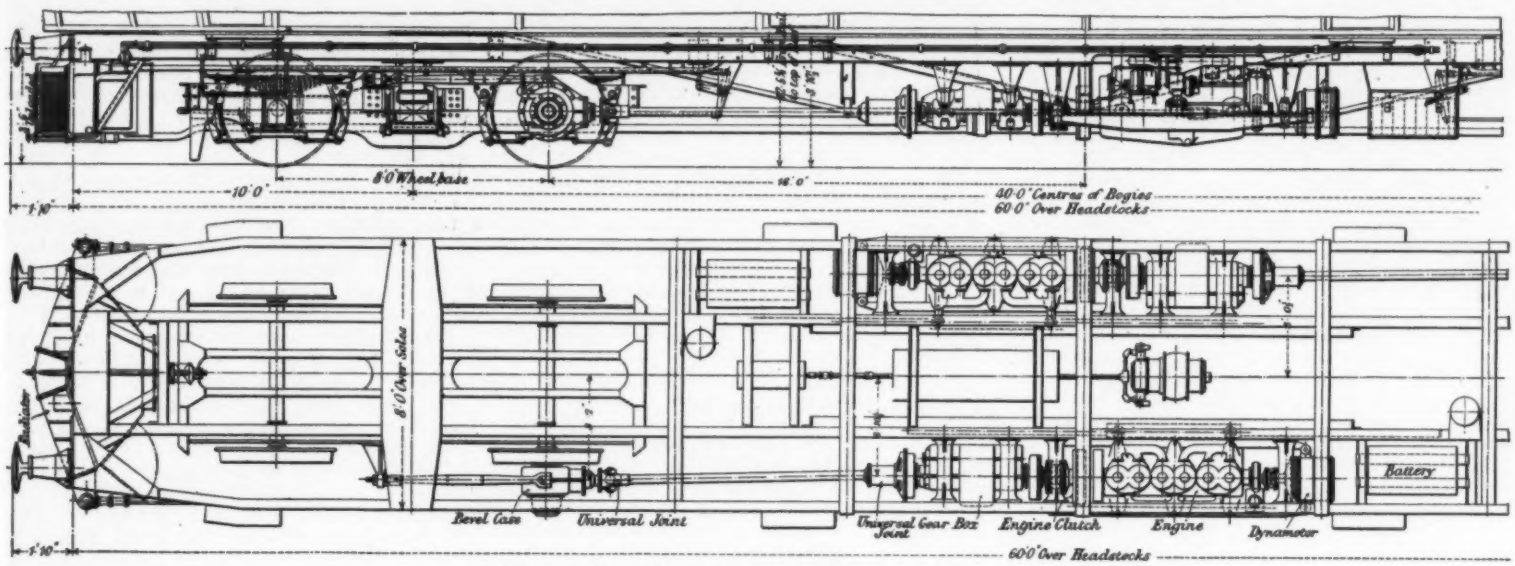
The reinforced guard shown on the left of the engraving was the means of saving a finger. The machine caught the guard, and its progress was arrested when it struck the reinforced tip. The operator quickly pulled his finger out, but in so doing he changed the position of the guard so that the tip slipped out of the way of the die and allowed the machine to continue its downward motion, crushing the part of the guard that was not reinforced. The operator escaped without injury.

* From the *Travelers Standard*.

The Geological Rôle of Fluorine

A very important communication has been made to the Academy of Sciences by Prof. Armand Gautier on the presence of fluorine in the igneous reactions of the nucleus of the globe. The work of the eminent chemist explains a geological fact misunderstood up till now—the existence of fluorine in all grounds of which it characterizes the direct or indirect igneous origin; in the virgin thermal springs, which are formed in the bosom of the igneous rocks, and in the eruptive or volcanic gases in which it had not before been observed. At the present time, M. Armand Gautier has been able to establish the fact that fluorine forms a part of all old rocks, that it always remains in the state of fluorite, apatite, etc., as well as in the waters that flow out of these veins. From all times fluorine has thus come out of the terrestrial nucleus, and it still continues to be produced. But up till now it had been impossible to realize this research in the eruptive gases for want of a method. M. Armand Gautier has succeeded in finding one and also in estimating it. In the month of August last, at an altitude of 1,080 meters, at the mouth of the volcano of Vesuvius, he managed to collect the gas of the fumaroles. In it he noticed some fluorhydric acid. He also collected, not far from Voltera, in the Tuscany beds of boracic acid, gases issuing from the soil at 160 degrees, and likewise containing free fluorhydric acid. The condensed water that accompanies these gases contains 3.72 milligrammes of fluorine. So then, whether we examine the old rocks, granites or porphyries, the soils that proceed from them, the mineral waters that flow from them, or the eruptive gases, always and everywhere fluorine is present and characterizes the igneous origin of these products. Fluorine, concludes Prof. Armand Gautier, for want of the means of following it up, has remained up till now the great misunderstood geological and physiological actor.—*Chemical News.*

There are seven spruces in the United States. Four are confined to the west; two to the east; while one, white spruce, has a continent-wide distribution.



Figs. 1. and 2.—Side elevation and plan of truck and motor.

The Internal Combustion Motor for Railways*

Will It Displace the Steam Locomotive in the Future?

By F. W. Lanchester, M. Inst. C. E.

THE steam locomotive, after having survived for nearly a century with all its essential features almost unchanged, appears to be about to yield supremacy on our railways to other methods of traction.

Development is at present taking place along two distinct lines, namely, (a) by the complete electrification of the system, in which case the prime mover is stationary, and the power is transmitted to the locomotive mechanism electrically; and (b) the substitution of the internal combustion engine for the steam-engine and boiler.

The development in this latter direction takes two forms: one in which the internal-combustion engine is virtually a portable power-station, and is employed to generate current, which in turn drives electric motors connected with the axles; and the other the method in which the power is transmitted mechanically to the axles as in an ordinary motor vehicle. It is to this latter branch of development that the present paper principally relates.

There is also a system which may be said to lie halfway between the portable electric installation and the motor-car type—a mixed gasoline electric. This has at various times received different names, but when discussed by the author in his presidential address to the Automobile Engineers it was termed the "electric auxiliary" system.

The factors that govern the choice of any system of locomotion are entirely different in different cases, depending upon the nature of the work to be done. An extreme contrast as illustrating this fact is found when an omnibus service destined to run in a hilly, populous district and a railway service to cover long stretches of fairly level country are compared. In the first case there are extreme fluctuations of load at frequent intervals, as due both to stopping and starting and to changes of gradient, but with a fairly constant average when a matter of half-an-hour's running is considered. In the second case, the high-speed railway service, on the contrary, the gradients are comparatively light, and the resistance is mainly windage; consequently extreme fluctuations of load are comparatively infrequent. The difficulty that arises in the case of the railway service is that the wind resistance is liable to enormous variation; whereas a following wind may in certain cases relieve the motor of some of its duty, a head wind or side wind may result in doubling or more than doubling the normal resistance.[1] Further, owing to the approximate constancy of direction of travel, abnormal resistances are not of a temporary kind, such as can be dealt with by storage, but require to be met by a definite reserve of horse-power; no storage system is competent to deal with sustained overload. The conditions in the case of railway locomotion are rendered still more exacting by the fact that a time-table has to be rigidly adhered to.

The steam locomotive has in the past shown itself singularly well adapted to take care of such varied conditions as above defined; it can always be maintained working at overload conditions by heavy and assiduous stoking, and by opening out the link motion to give later cut-off. It is one of the problems to be faced in applying the internal-combustion engine to similar duty, how to provide for the additional tractive effort under emergency conditions.

One salient fact connected with the problem is that the really severe overload conditions occur, comparatively speaking, infrequently, the extreme cases only occurring perhaps some dozen or twenty times in the course of a year. From economic considerations it is evidently, therefore, not feasible to meet the difficulty by a mere increase in the size of the power unit; the running of a big power unit under throttle for 350 days out of 365 days at about a third or half its full load would be in itself sufficient condemnation of that method of meeting the difficulty. On the other hand, as already pointed out, it is impossible to meet the conditions in the case of railway traction by power storage of any kind, for, contrary to the position of the road automobile, the overload conditions, when they do occur, are of a permanent character, and the resources of a storage system, however ample, would speedily be exhausted.

The first idea that suggests itself to deal with the special conditions of railway work is to provide, in addition to the main power installation, an auxiliary or supplementary power installation which may be brought into action when occasion arises. The author of the present paper actually worked out a scheme and took out patents covering an arrangement of this kind, in which the main power installation was arranged to drive directly through a suitable reduction gear on to an axle or axles, and in which the supplementary power plant was arranged to drive electrically, the arrangement, so far as the

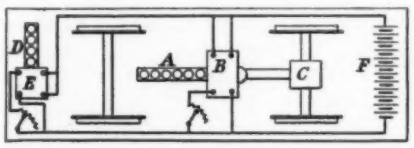


Fig. 3.—Auxiliary unit system.

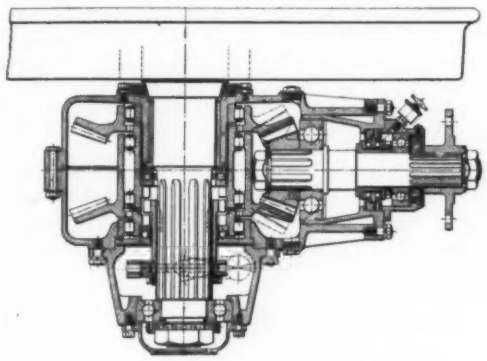


Fig. 4.—Reversing gear.

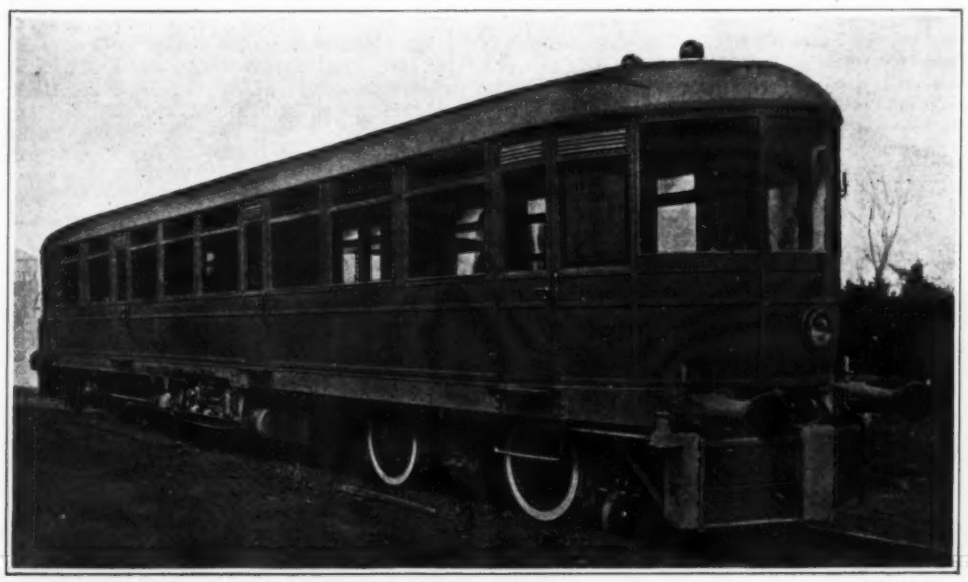


Fig. 5.—Sixty-passenger gasoline coach.

*Paper read before the Engineering Section of the British Association at Birmingham.

[1]In a train consisting of several vehicles the side wind as affecting resistance is of relatively greater importance than for the single self-propelled coach.

supplementary unit is concerned, being a complete electric transmission, the internal-combustion engine being coupled direct to a dynamo forming the generating unit, and an electromotor, either coupled to the main power installation or to one of the car axles, being employed to transmit the power, an accumulator battery being employed to take care of incidental torque variations such as required at starting and during acceleration. The scheme included means of starting either internal-combustion engines electrically or in handling the car electrically for shunting work, etc., from the storage battery. The whole scheme is represented diagrammatically in Fig. 3, and is described in detail later.

The scheme, as above outlined, although in all respects forming a solution to the difficulties of the problem, was not carried out, having given place in turn to the scheme of arrangement subsequently described in the present paper. The author considers, however, that it is a scheme that may yet show advantages in certain applications to railway locomotion, and in nowise regards it as definitely abandoned. It ought in practice to be superior to the complete electric transmission system (which is being considerably employed on the Continent and elsewhere), owing to the fact that the greater part of the power transmission is direct, and not subject to electric losses. In cases where there is a great deal of starting, stopping, reversing, etc., and in other cases where short, steep gradients are encountered—that is to say, in brief, where the conditions approximate more nearly to those of a tramway than a railway as we know it in this country—the author believes that the scheme (Fig. 3) possesses unique features that render it exceptionally well adapted to take charge of the conditions. On regular railway work, however, it has given place as a definite matter of logic to a scheme of altogether simpler character.

It is evident in examining the problem closely that if a given number of cylinders of a certain size are being employed in the design of the power unit of a given automobile railway coach, the ultimate capacity being sufficient to give the horse-power for emergency conditions, we may either, as in the preceding scheme, arrange to utilize, say, half the total number of cylinders to deal with ordinary conditions, or we may, still using the whole number, arrange to work them under less severe conditions. Putting the matter in concrete form, we have the alternative of running, say, two four-cylinder engines as separate units, or we may couple them together and run them at less than their full output under ordinary working conditions. There are two ways of running an internal-combustion engine at less than its full output: (*a*) by governing or throttling, (*b*) by reducing revolution speed. The first of these we have already condemned as uneconomical; it is the method used in general on road automobiles, it is the method used on gas-engines employed to drive factories. In the road automobiles economy is not usually a matter of first importance; in the running of a factory the load is frequently constant, or nearly so, and where it is not it is common practice to employ several power units that can be brought into requisition as occasion demands, resembling in some degree the scheme already discussed. When, however, we take as our basis the method of running the engine slowly, we find that we have a far better proposition; an internal-combustion engine can be run over considerable range of variation of speed without material loss of efficiency or economy. The alternative scheme therefore becomes one in which we have an internal-combustion engine of sufficient capacity to deal at its highest proper running speed with the overload conditions—that is to say, to drive the coach or train continuously under the worst conditions of head wind or side wind, and under normal conditions we arrange to run the same motor at such lower speed as would develop the power normally required. This scheme involves at least two different running gear ratios: on the higher gear the motor will paddle round slowly and will give sufficient torque on the driving-axle for ordinary fine-weather conditions; the second (lower) gear is provided with a ratio of about 3 : 2, to give the same speed of travel for an increase of 50 per cent in the engine revolution speed. Taking a concrete case, an installation might be specified in which an engine capable of commercially running at 1,200 revolutions is geared on its higher gear to give a running speed of 45 miles an hour at 800 revolutions of the motor, and a tractive effort of, we will say, 1,000 pounds, this being estimated as necessary under ordinary running conditions; under these conditions we have the engine running considerably under its designed speed, and therefore under conditions in which the wear and tear will be minimized. Under emergency conditions the lower gear is thrown into action, and the car speed is maintained at 45 miles an hour, the engine now running at its full speed to 1,200 revolutions, and providing a tractive effort of 1,500 pounds—that is to say, 500 pounds additional tractive effort to overcome abnormal wind resistance.

At first sight one may be inclined to make the comment that the above argument is merely a roundabout way of demonstrating the utility of the ordinary motor-car change gear, but on a closer examination it will be found that while intrinsically there is nothing new in the way of invention in the scheme as laid down, there is a considerable difference as to the aim and object achieved. It is important to be quite clear on this point, as it affects fundamentally the choice of gear ratios required and the type of gear-box appropriate to the service. On the ordinary road automobile change-speed gears are used for the same broad purpose, namely, to increase the torque on the driving-axle in order to overcome exceptional conditions of resistance, usually due to adverse road gradients, and to a lesser degree due to a heavy road surface and head wind. In the road automobile, however, the full power of the engine is in practice more often developed on the high gear than on one of the lower gears; the driver does not, and has no intention of, confining himself to such a speed as he could always accomplish on his next to highest gear. The conditions would be more strictly comparable if the present-day motor-car were driven consistently within our so-called legal limit. Thus most cars can be easily driven at 20 miles an hour on the next to highest gear with a reasonable speed of engine rotation, and then under normal conditions the car would be run at the same speed with the engine going easy at about two thirds or three quarters speed. The two main facts to which attention is drawn at the present juncture, are that the ordinary road motor-car is not driven in this manner, and the type and occurrence of the emergency conditions are entirely different in the two cases. The importance of these points is a bearing when it comes to the selection and consideration of gear ratios for railway work.

If we examine in detail the nature of the resistance to traction, and for the purposes of analysis we take the case of a 60-foot bogey-coach weighing 30 tons, we find it, roughly, to be made up as follows:

	Pounds.
Rolling and axle friction at 0.3 per cent	200
Wind resistance at 48 miles an hour	400
Total	600

It is necessary to allow something in addition to the above as the "ordinary" resistance. Firstly, it is not uncommon (in this country) to find in a run of 30 or 40 miles,[1] a change of altitude of five or six hundred feet, that is to say, a mean gradient of about 0.3 per cent, representing an additional tractive effort of about 200 pounds. Beyond this the normal tractive effort must always be capable of taking care of a moderate summer breeze, so that in computing the ordinary windage velocity some 10 or 15 miles an hour higher than the actual train speed should be taken, our normal resistance account thus becomes:

	Pounds.
Rolling and axle friction	200
Windage calculated on 60-miles-an-hour basis for speed of 48 miles an hour	600
Incidental gradient resistance	200
Total	1,000

We will now draw up a similar table of resistance for exceptional circumstances, and assume a head wind of 36 miles an hour[2] as representing the worst condition to be encountered without loss of speed.

	Pounds.
Rolling and axle friction	200
Wind resistance	1,150
Incidental gradient	200
Total	1,550

The total resistance is thus increased slightly more than 50 per cent by the adverse conditions assumed.

It is more than probable that occasional weather conditions will arise which are not adequately represented by a 36-mile-an-hour head wind, in such cases we have candidly to admit that our railway coach will be unable to keep time if billed to make a consistent 48 miles an hour; but we know that, as a matter of experience, exceptional weather of this kind is capable of disorganizing railway traffic run under existing methods. We may now compare the horse-power required in accordance with the above *régime* under ordinary and emergency conditions.

Ordinary Conditions.—Forty-eight miles an hour is approximately 70 feet a second; at 1,000 pounds traction we have 7,000 feet-pounds per second, or 127 draw-bar horse-power required. At a transmission efficiency of 94 per cent, the brake horse-power required would be 135.

Emergency Conditions.—The draw-bar horse-power required, say, 190 horse-power at 90 per cent efficiency, gives 210 brake horse-power.

In practice, it must not be supposed that any hard-and-fast point will arise at which it will be necessary to change from the high gear to the low gear over the whole route traversed. As the weather conditions become worse and worse, the driver, in order to keep time, will require to run over longer stretches of his road on the low gear with the engine "at speed," and naturally the sections over which at first his low gear will be brought into requisition will be the sections of his road where the gradient is adverse or where the track is exposed to the full fury of the gale. In spite of this, it is evidently desirable to extend the scheme of change-speed gear to provide something intermediate between the two ratios hitherto assumed, a double advantage being gained: firstly, the occasions on which the engine speed is to be pushed to its highest point will be far less frequent; and secondly, consequent on this, it will be permissible to somewhat widen the ratio, and so enable the driver to cope with even worse conditions than those set forth. The author has adopted in his most recent design of gear-box a ratio of approximately 1 to 1.6, divided into two equal steps, giving corresponding motor speeds approximately 800, 1,000 and 1,300 for the engine revolutions at standard running speed of coach.

Having definitely adopted change-speed gear mechanism as the solution of the problem of railway traction, the electrical portion of the power equipment becomes of minor importance, and it may be said to become the object of the designer to get rid of it as far as possible; it is, in fact, reduced virtually to a lighting and starting set, such as is commonly employed to-day on an ordinary motor-car, with the additional provision of an electric air-compressor to work the Westinghouse brake.

So long as one contemplates the use of heavy electrical installations it is both convenient and natural to throw the onus of providing for acceleration from the electrical side of the equipment; but when once the functions of the electrical equipment are reduced to such secondary duties as aforesaid, it is necessary to look elsewhere, and, in brief, to provide acceleration by means of an additional low gear.

For ordinary main-line railway work the acceleration rarely in practice exceeds 0.6 or 0.8 poundals per pound, but this is found to be insufficient to meet modern requirements. It is one of the weak points of ordinary steam-locomotive railway traction that high accelerations are not obtainable; the time lost in stoppages under the old conditions of railway traction are such as to prohibit anything in the nature of stoppage where high average speed is important; it may be taken as essential that in the traction of the future accelerations up to 2.5 feet-seconds per second (2.5 poundals per pound) should be obtainable. The tractive effort on the high gear, 1,000 pounds, represents approximately 1.55 per cent, or 0.5 poundal per pound; if, therefore, for starting we use a gear giving one fifth the speed of the high gear, we shall, up to the limits of the speed of such a gear, be able to obtain an acceleration of about 2.5. At first sight it might be thought useless to provide a lower gear than this, for on the one hand we are getting near the point at which skidding of the wheels on the metals takes place, and on the other we are reaching accelerations that it is customary to regard as near the limit of what can be deemed comfortable from the point of view of the passengers; there are, however, other facts to consider. There is considerable prejudice against the separate starting of engine and car in railway work; there are strong objections (whether well-founded or ill-founded) to the running of the motor while the car is at rest at the platform, and there is no doubt that any system that involves the separate starting of the engine and the car will excite prejudice and encounter considerable opposition from railwaymen. It is therefore desirable to fit an extreme low gear so low as to allow of the engine and car being started simultaneously, or, in motor-car phraseology, with the "clutch in."

Having settled the broad lines on which to work, there still remain several important problems of a quasi-engineering character to be dealt with. A

[1] The gradient resistances for short distances, such as a mile or two of ascent or descent such as are commonly met with on British Railways, do not require special provision. They average up on a long run, and the kinetic energy of the car in motion is capable of taking care of such temporary fluctuations of tractive effort.

[2] This corresponds to a far higher wind velocity as measured by the anemometer at a distance from the ground.

decision has to be made as to the most suitable manner of application of the system to the needs of railway work. The practice almost universally adopted, where steam is employed, is that of an independent locomotive engine of sufficient weight to secure the adhesion necessary for the drawing of a train of coaches or trucks; thus we have the whole power used for traction approximated through one, two, or three axles, entirely confined to the locomotive itself. In the case of electrical traction we find that commonly the reverse is the case, and that the power units are distributed over a greater number of axles.

If in the adoption of the internal-combustion engine we were to endeavor to follow ordinary railway practice and mount the power unit as a separate locomotive engine, we should be throwing away one of the great advantages possessed by the internal-combustion motor, namely, its lightness. A modern gasoline-motor-car engine weighs anything from 10 pounds to 15 pounds per brake horse-power, and with radiator and cooling water and gasoline sufficient for two hours' running, the additional weight is only approximately 20 per cent, say, from 12 pounds to 18 pounds per brake horse-power. In contrast to this, an ordinary steam locomotive will weigh, with its complement of water and fuel, approximately a hundredweight per horse-power, so that properly applied, an enormous saving of the gross weight to be transported can be effected by the employment of the internal-combustion engine. This saving, however, cannot be realized unless the motor or motors are mounted on the coaches themselves; for if the internal-combustion engine is merely embodied in the design of a locomotive, it is necessary, in order to secure adhesion, to make up the necessary weight by the employment of useless ballast or heavy construction. If, therefore, the full advantage of applying the internal-combustion engine is to be realized, it will be by the application of the power-units to the individual coaches or trucks. It is worthy of remark that, even in the case of steam, there have been several tentative efforts of recent years to embody a miniature steam locomotive in the design of a passenger coach. Such vehicles are used to some extent on our British railways, notably, doing branch-line work on the London, Brighton and South Coast and Great Western Railways.

The author will now describe the latest development in the direction of the gasoline coach embodying the principles set forth in the present paper. The coach in question, Figs. 1, 2, and 5, is a full-size 30-ton bogie coach having a capacity for sixty passengers, and propelled by two entirely independent power units carried externally on opposite sides of the main frame. Each power unit comprises a six-cylinder gasoline or petroleum-motor arranged to drive through gear-box on to bevel transmission mounted on a prolongation of one of the bogie axles (Fig. 4); the transmission from the change-speed gear-box to the axle being by coupling-shaft and Hooke's joint after the manner customary in motor-car practice. The motor and change-speed gear are mounted on a pair of longitudinal members, which also carry at their tail end a dynamo direct coupled to the engine, whose function is to start the engine and take care of the lighting and the electrical air-compressor. The whole of the power unit so constituted is suspended from the transverse members of the coach frame on spring mountings, by means of which the effects of engine vibration, gear noises, etc., are eliminated.

Driving-cabins are fitted at each end of the coach, and the whole equipment is entirely symmetrical, so that, properly speaking, it has no front and no rear; the reversal is effected by the double bevel-gear drive and dog-clutches (Fig. 4). The driving-cabins occupy the "faired" ends of the coach, which, in the language of naval architects, constitute the "entrance" and "run" of the vehicle. The air resistance of the car as determined by model experiments is approximately half that of a normal plane of the area of maximum cross-section.

In all the main features the proportions of parts, sizes of wheels, axles, etc., and strength of frame members, follow established railway practice; and, the floor level, which is approximately the customary height, is unbroken from end to end, the whole of the power installation (which, with the exception of the controllers, rheostats, etc., arranged in the driving-cabins) is well below the floor level.

The design of gear-box finally adopted is the outcome of considerable experiment and careful study of the problem. The most salient features of this gear are the magnetic-clutch actuation and the use of gear-boxes in tandem.

The trials of this vehicle are not at present completed, but for acceleration and maintenance of speed it has done almost better than expected, the distance from Nuneaton to Coventry having been traversed, including starting and stopping, at over 60 miles an hour; the riding at this speed leaves little to be desired.

A few points may be added on the question of fuel consumption. Taking the speed at 48 miles an hour, which is that assumed as the basis of calculation of the present paper, we have seen that under ordinary conditions 135 horse-power will suffice for propulsion. This includes an incidental gradient representing approximately one eighth of the total on the horse-power; corrected for an average of level running we have 120 horso-power approximately. Assuming 0.6 of a pint of gasoline or petroleum per horse-power hour, the consumption per hour will be 72 pints, or 9 gallons, that is to say, 5.33 miles per gallon, or 160 ton-miles per gallon. This calculation can conveniently be put in another form. The energy *available* from a gallon of gasoline, assuming 22 per cent as the total (thermal and mechanical) efficiency of the motor, is 24,000,000 feet-pounds. The resistance (assuming an average level) according to the foregoing computation is 800 pounds; the weight of the coach being 30 tons, the foot-pounds per ton-mile will be $800 \times 176 = 141{,}000$, or ton-miles per gallon of gasoline will be $\frac{24{,}000{,}000}{141{,}000} = 170$ ton-miles to the gallon. The difference is due to the fact that the second calculation does not take account of the transmission efficiency loss; there is also a slight unimportant difference in the data on which the calculation is based. Recent tests have confirmed these ton-mile figures, over 170 ton-miles per gallon being recorded at an average speed of well over 40 miles per hour.[4] As an illustration, a 30-ton coach, in traveling from Birmingham to London,[5] would consume approximately 20 gallons of gasoline, which, at the present contract price of gasoline (such as would be paid by a railway company), the cost of fuel works out between 10 to 12 shillings; if we assume 40 passengers as the load carried, the fuel charge for the distance (Birmingham to London) will amount to a trifle over 3 pence per head. It is evident, therefore, that the cost of fuel, even if only refined grades of petroleum spirit can be used, is not a very serious matter.

There is a great deal that will require to be learned by experience on the question of handling independent units, such as are constituted by self-propelled coaches on our railways. The problem of coupling up a number of gasoline coaches under the control of the leading driver's cabin has yet to be worked out. There are no insuperable difficulties in the problem, but it may be anticipated that there will be a great deal of detail to be thrashed out, and a considerable amount of prejudice to be overcome. It is uneconomical from the point of view of railway management to subdivide a train before it is necessary owing to the fact that each portion of the train requires to be separately signalled and sent on, and occupies in transition a complete section of the block system. At the same time, if the gasoline-coach is to do all that is hoped of it, it will eventually become more than a mere feeder on branch-line duty. If in the future independent coaches can be coupled up to form trains under control of the leading cabin and be uncoupled to form independent sections at various junctions on the line, a great economy will result in railway administration and the convenience of the public will be far better served than at present. Thus, a train of some eight or ten coaches could leave London and travel express to such a point as Rugby, where it could divide into sections, and again, say, at Crewe, each component coach eventually reaching its own appointed destination, direct high-speed communication from the Metropolis thus being established over an indefinitely wide area.

Auxiliary Unit System.—In this system, Fig. 3, an engine *A* is directly coupled to the axle-driving box *C*. It carries the armature of a shunt-dynamo *B* on its flywheel. An auxiliary engine *D* drives a shunt-dynamo *E*. These machines are coupled in parallel with the battery *F;* by the regulation of the field resistances of the machines the auxiliary may be used to assist the engine, charge the battery, or do both; the machine *B* may be driven by the battery, the above providing a self-starter, an auxiliary for adverse conditions, and a reverse for acceleration purposes, while maintaining the direct drive for normal conditions.

[4] In some of the test runs made 200 ton-miles per gallon has been exceeded.

[5] The distance from London to Birmingham, England, is just over 120 miles.

A Few Miscellaneous Accidents

CERTAIN occupations are well known to be hazardous, and many of the dangers that are connected with them are easily recognized. Others appear to be harmless, but peril in one form or another is always present, even when it is not immediately apparent. The farmer's life is often pictured as particularly safe, and yet it can be shown that accidents are more numerous in agriculture than they are in any other pursuit. The housewife, engaged in the peaceful occupation of caring for the welfare of the family, also seems to be in no great danger of receiving accidental injuries, but there are countless ways in which such injuries may befall her. In fact, one cannot be sure of one's own safety at any moment, nor under any circumstances. The following short items, which emphasize this fact, were mainly taken from the newspapers, and anyone who desires to do so can multiply their number indefinitely. These accidents are all somewhat unusual, but they are no more so than thousands of others that befall persons who lead quiet, secluded lives, or who are engaged in work of an apparently harmless nature.

The hair of a woman operator in a Cleveland worsted mill became entangled in the mechanism of a spinning machine, and before the machine could be stopped her scalp had been completely torn off.

A lineman had a narrow escape from death while working at the top of a condemned telegraph pole. The pole, which stood beside a railroad track, broke as a train was passing at high speed. The man was thrown just clear of the train and was stunned by the force of his fall, but was not seriously injured. The crossarms of the pole struck the cars.

An extraordinary accident occurred some time ago in Pennsylvania. A man who was taking a short vacation decided to employ a part of the time in making some repairs about his home, and he was setting up a stove pipe, which was said to be heavier and larger in diameter than is ordinarily used. Part of the pipe was in position, and he was standing underneath it, when it suddenly became dislodged and fell down over his head, cutting off both ears as neatly as though the work had been done with a knife.

Even the homely occupation of churning for butter is attended with some danger, as is shown by the case of a Kentucky woman. One account states that she "was churning cream in a closed half-gallon jar, when gas formed on the cream and caused the jar to burst. A piece of the glass was hurled against her arm with such a force that an artery was severed." We are in the dark as to the nature of the gas that is mentioned, and are strongly inclined to believe that it was a too vigorous manipulation of the dasher that caused the glass to break. However this may have been, the accident shows that there is an element of danger, well worth consideration, in the use of glass jars for churning.

Two men were working upon a swinging scaffold suspended over an industrial railway in a steel plant in Ohio, when a passing "dinky" locomotive caught the rope by which the scaffold was raised and lowered, and pulled it down. One of the men fell beneath the locomotive and was killed, and his fellow worker, in falling, struck the engine and rebounded from it to the ground receiving serious injuries.

The hazards of the blacksmith's trade are illustrated by the following: A vicious mule that needed to be shod was taken to a blacksmith who knew nothing of the ugly disposition of the beast. While a shoe was being fitted to one of the mule's front feet, the animal seized the blacksmith's trousers with his teeth and threw the man to the floor, breaking one knee and causing other injuries. The blacksmith sued the owner of the mule for $6,000. We have not learned the result.

An operator of a punching machine recently met death in an unusual manner. The machine started up while he was tightening a nut on it with a monkey wrench, and he was unable to remove the wrench. It revolved at high speed for a few seconds, and was then thrown off, striking the man on the head and crushing his skull.

Four men were seriously injured by the explosion of a keg of powder in an Ohio coal mine. The explosion was brought about by a mule, which kicked a wire and caused sparks to fly into the powder.—*The Travelers Standard.*

A Unique Village for workmen is to be erected by the contractors who will construct the Rogers Pass Tunnel on the Canadian Pacific Railway at Glacier. It is a region of heavy drifting snow, and the houses will accordingly be built 8 or 10 feet above the ground and connected by elevated bridges. This town on stilts will cost about $50,000.

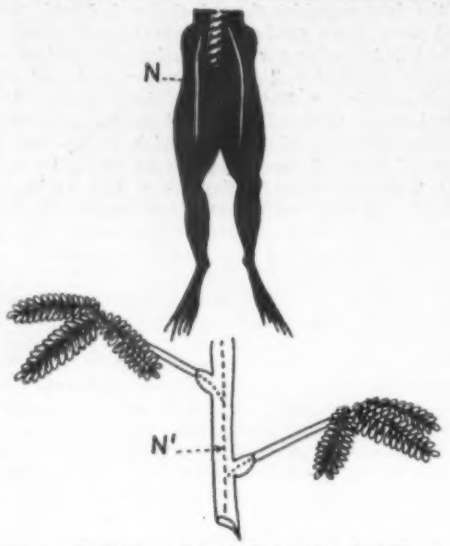


Fig. 1a.—Excitations of frog's limb and leaf of *Mimosa*. *N*, animal nerve. *N'*, conducting tissue of plant. The specimens are here shown in the rest condition.

The Speed of Nervous Impulse in Plants*

How Sensitive Plants Were Made to Record Their Own Reaction Time

By Prof. J. C. Bose, M.A., D.Sc., C.S.I.

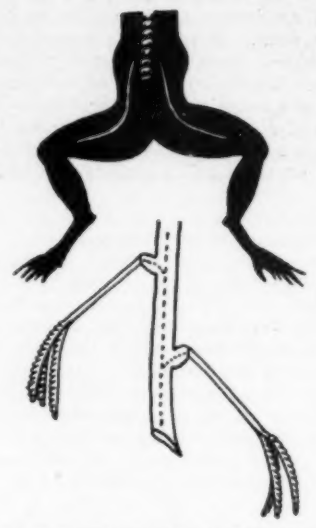


Fig. 1b.—The cushion-like tissue or pulvinus at the leaf joint of *Mimosa* contracts under stimulation inducing fall of leaf. Compare the corresponding reaction in the frog.

Do plants possess a nervous system? Before we attempt to answer this question we should form a clear idea of the function of a typical nerve. Of this it may be said that its principal function is the transmission of excitation from one point to another, more or less distant, by means of certain conducting fibers. By this process a living organism as a whole is brought into intimate relation with its environment. Thus stimulus from outside impinging on the retina gives rise to a nervous impulse which carried on to the brain by means of the optic nerve induces the response of luminous sensation. Instead of terminating in the brain the nerve may be led to a contractile muscle; the nervous impulse in such a case induces a twitch of the muscle.

Physiologists demonstrate the characteristics of nervous impulse by experimenting with a nerve-and-muscle preparation. For this the sciatic nerve of the frog with the attached muscle is dissected out. This isolated preparation can be maintained alive for several hours. If now a distant point of the nerve be stimulated by a mechanical blow or by an electric shock, an impulse will be transmitted along the nerve to the terminal muscle and induce there a sudden answering twitch. This way of transmitting excitation, where the effect of a blow applied at a point is exhibited by motile effect at a distant point, would appear not unlike what occurs in the sensitive plant *Mimosa*. Here also the application of stimulus, say of a pinch, on the stem or stalk gives rise to a wave of disturbance which traveling onward reaches the motile organ. In *Mimosa* this is situated at the leaf-joint where the pulvinus, like the animal muscle, contracts under excitation. Under the transmitted effect of stimulation, there occurs a twitch of the muscle of the frog, or a jerky fall of the leaf of *Mimosa* (Fig. 1). The conducting tissue in *Mimosa* lies buried inside the stalk or stem, and it is difficult to isolate it. In the case of fern, however, it is quite easy to dissect out certain fibrous tissue which acts as a conductor of excitation.

Though the effects produced in the animal and plant are so similar, yet from the results of certain experiments carried out by the leading plant physiologist, Pfeffer, it had been definitely settled that in the plant there is nothing corresponding to the nervous impulse in the animal. The effect transmitted in the plant is supposed to be one of hydro-mechanical blow and not of true excitation.

MECHANICAL VERSUS NERVOUS TRANSMISSION.

According to the hydro-mechanical theory, the turgid plant tissue is imagined to be like an India-rubber tube filled with water. The application of mechanical stimulus is supposed to squeeze the tissue, in consequence of which the water forced out delivers a mechanical blow to the contractile organ of the plant (Fig. 2). The propagation of mechanical disturbance is thus occasioned by the bodily transfer of fluid material in a pipe. In strong contrast to this is the transmission of nervous impulse, which is a phenomenon of passage of molecular disturbance from point to point. The particles constituting the living nerve may be regarded as possessing great molecular mobility. The incidence of stimulus induces a molecular upset in the nerve, and this condition of upset is known as excitation. When the nerve is very much alive, or in a very favorable physiological condition, then its molecular mobility is at its optimum. The impact of the feeblest stimulus then causes a great upset and therefore intense excitation. Physiological depression, however induced, will on the other hand give rise to a corresponding depression of excitability, culminating in its abolition at the death of the living tissue.

The molecular disturbance constituting excitation,

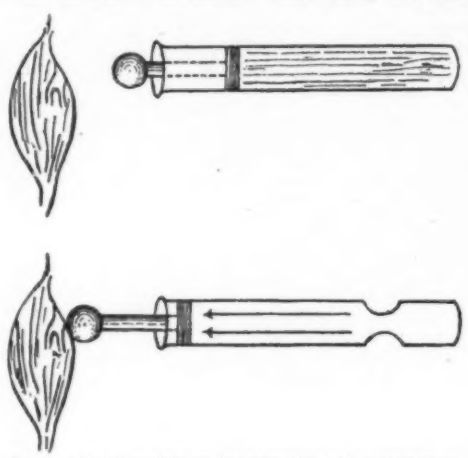


Fig. 2.—Model explaining hydro-mechanical transmission. Propulsion of water brought about by pinching of India-rubber tube makes the piston strike the contractile tissue to the left (lower figure).

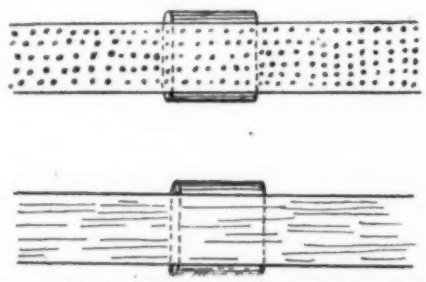


Fig. 3.—Transmission of excitatory molecular disturbance (upper figure) and of water movement (lower figure). Application of a depressing drug in an intermediate zone arrests nervous impulse, but has no effect on the mechanical movement of water.

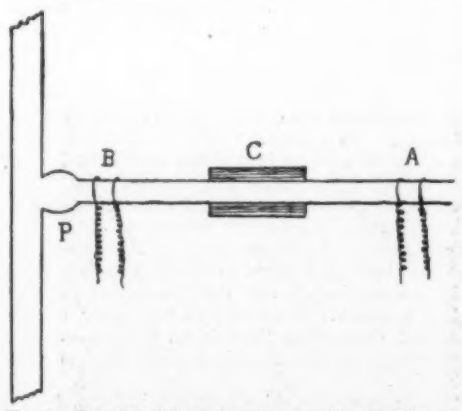


Fig. 4.—Experimental arrangement for determination of velocity of transmission and its variation. First record taken when stimulus is applied on the leafstalk at *B* (latent period) and then at a distant point *A*. Difference of two gives time for transmission from *A* to *B*. The band of cloth *C* is for local application of warmth, cold, anæsthetics and poison.

passes along the conducting nerve, and this point-to-point propagation of molecular upset is known as the transmission of excitatory or nervous impulse. If by any means the physiological activity of a portion of the nerve be enhanced then excitation will pass through the particular portion with quickened speed. Such favorable condition is brought about by the application of moderate warmth. If a portion of nerve on the other hand, be rendered physiologically sluggish, then the speed of nervous impulse through that portion will be slowed down. There are certain agents which temporarily paralyze the nerve for the time being, causing a temporary arrest of the nervous impulse. Such agents are known as anæsthetics. There may again be poisonous drugs which destroy the conducting power. Under the action of such poisonous agents the nervous conduction is permanently abolished (Fig. 3).

We are now in a position to distinguish between mechanical and nervous transmission. The mechanical conduction of water through a pipe will in no way be affected by warmth or cold; the pipe will not lose consciousness and stop the flow of water, if it be made to inhale chloroform; nor will its conducting power be abolished by applying round it a bandage soaked in poison. These agents will, on the other hand, profoundly affect the transmission of excitation. The nature of an impulse may thus be discriminated by crucial tests:

If physiological changes affect the rate of conduction, then the impulse must be of a nervous character; absence of such effect on the other hand proves the mechanical character of the impulse.

Of the various physiological tests, the eminent German physiologist, Pfeffer, employed only one, namely that of the narcotic drug. Chloroform applied on the *surface* of the stem of *Mimosa* failed to arrest the impulse. This result at first sight appears most convincing and has been universally accepted as a disproof of the existence of nervous impulse in *Mimosa*. A little reflection convinced me, however, that under the particular conditions of the experiment, the conducting tissue in the interior could not have been affected by the external application of the narcotic, the task being in fact, as difficult as narcotizing a nerve-trunk lying between muscles by the application of chloroform on the skin outside.

The question of nervous impulse in plants has thus to be attacked anew and I have employed for this purpose twelve different methods. They all prove conclusively that the impulse in the plant is identical in character with that in the animal. Of these I give below a short account of three different modes of investigation. It is obvious that the transmitted impulse in *Mimosa* must be of an excitatory or nervous character:

(1) If it can be shown that physiological changes induce appropriate variation in the velocity of transmission of the impulse.

(2) If the impulse in the plant can be arrested by different physiological blocks by which nervous impulse in the animal is arrested.

(3) If excitation can be initiated and propagated without any physical disturbance. The central fact in the mechanical theory is the squeezing out of water for starting the hydraulic impulse; the hydro-mechanical theory must necessarily fall to the ground, if stimulation can be effected without any mechanical disturbance whatsoever.

The research ultimately resolves itself into the accurate measurement of the speed with which an impulse in the plant is transmitted and the variation of that speed under changed conditions. A portion of

* Abridged from *The Modern Review*.

Fig. 5.—Two successive records exhibiting identity of latent period. Recorder tuned to 100 vibrations per second. Distance between successive dots represents one hundredth part of a second. Vertical line indicates the application of the stimulus.

the tissue at *C* may, for example, be subjected to the action of cold or of an anæsthetic. In order to find the speed of normal transmission we apply an instantaneous stimulus, say, of an electric shock, at *B*, near the pulvinus (Fig. 4). A short interval will be found to elapse between the application of stimulus and the beginning of responsive movement. There is a certain time lost to start the motile mechanism in action, and the time taken by the plant-organ to perceive and give an answer to the incident blow, is known as the *latent period*. After the determination of this latent period, we apply stimulus once more at *A*, and observe the time which elapses between the application of stimulus and the response. The difference between the two periods gives us the time required for the excitation to travel from the point of application of stimulus at *A*, to the responding organ at *B;* hence we obtain the speed of impulse in the plant. The experiment is repeated once more, after the application of a given agent at *C*. If the speed undergoes any variation, it must be due to the action of the given agent.

In making these measurements the results are vitiated by our personal limitations. The conditions of the experiment demand accurate measurements of time-intervals shorter than a hundredth part of a second; but sluggishness of our perception makes such an attempt an impossibility. It is therefore absolutely necessary to invent a special device by which the plant itself should be compelled to write down the propagation speed of its own excitation.

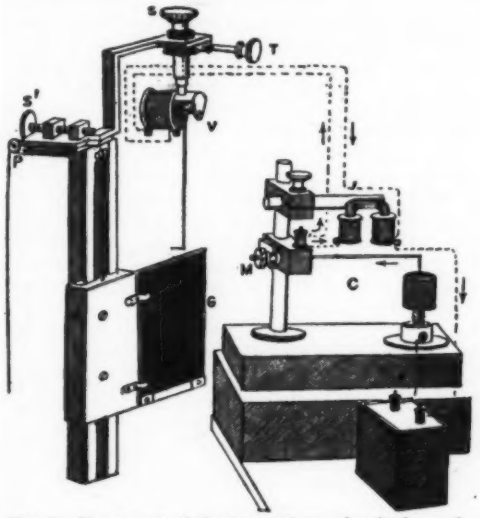


Fig. 9.—Upper part of the resonant recorder *C*, the reed and *V*, the vibrating writer, both tuned to, say, a hundred vibrations per second.

A theoretical way of doing this would be to make the plant give a record from which the speed of the impulse in the plant is found. The leaf of *Mimosa* is attached to one arm of a lever *V*, by means of a thread (Fig. 10). A long wire *W*, bent at the tip, is placed at right angles to the lever. The tip of the writer touches a smoked glass plate *G*, which is allowed by means of

Fig. 12.—Effect of cold in inducing retardation and arrest of transmission. (1) Normal record, (2) retardation due to slight cooling, (3) arrest of conduction by application of ice, (4) record of direct stimulation of pulvinus.

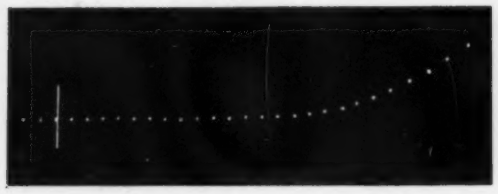


Fig. 6.—Another record of the latent period of *Mimosa*. This recorder vibrates 200 times per second. The time-interval between successive dots is here 0.005 second.

a clock work, to fall at a definite rate. By some mechanism an electric shock is given to the leaf stalk at *A*, at the precise moment marked by the arrow. This is done by the rod *R*, attached to the glass plate *G*, making a short-lived electric contact with *R'*, during

Fig. 8.—Determination of velocity of transmission in *Mimosa*. The two lower records are in response to stimulus applied at a distance of 30 millimeters; the upper record exhibits latent period in response to direct stimulus applied on the pulvinus. Successive dots in this and following records are at intervals of one tenth part of a second.

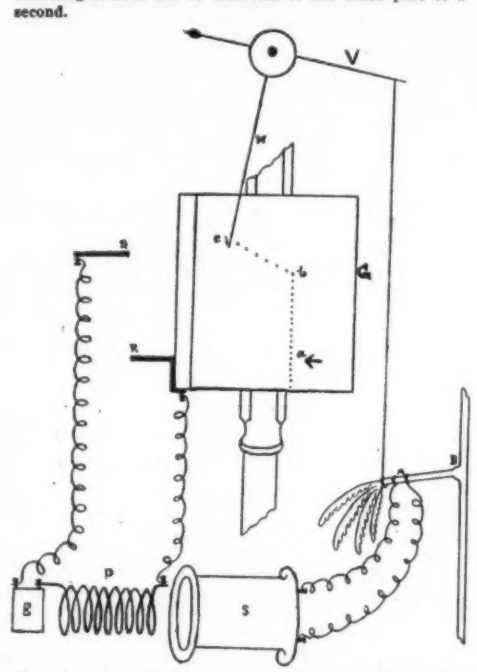


Fig. 10.—Diagrammatic representation of plant-recorder. Responding leaf attached to one arm of lever *V*, at the fulcrum of which is attached *W*, the writer. *G*, sliding smoked glass plate for record. Recording plate is lifted and allowed to drop. At a definite position during fall, *R* makes momentary electric contact with *R'*, giving rise to instantaneous electric shock at *A*. Moment of application of stimulus marked on recording plate by arrow *a;* arrival of excitation at *B* causes fall of leaf, which pulls the writer to left discribing *bc*. For determination of latent period, stimulus is applied on the pulvinus at *B*.

the fall. After a definite period, the leaf is observed to fall. Up to this time the leaf remained unexcited, and an up-line *ab* is traced on the glass plate; the responsive fall of the leaf then pulls down the lever

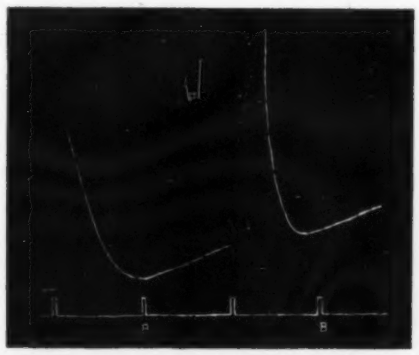


Fig. 13.—Records of transmitted excitation with the electric block "off" and "on" alternately. Arrest of transmitted excitation under electric block at *BB*.

Fig. 7.—Effect of rising temperature in enhancing velocity of transmission. The three records from below upward are for temperatures 22 deg. Cent., 28 deg. Cent., and 31 deg. Cent., respectively.

causing a sudden jerk of the writer to the left indicated in the record as *bc*. Thus the length *ab* in the record represents the interval between the application of stimulus and the beginning of responsive movement. Suppose the recording plate had been adjusted to fall at the rate of one tenth of an inch per second, and the distance *ab* was found to be three tenths of an inch; it is then clear that this represents an actual time-interval of three tenths of a second. This is the time occupied by the impulse to travel the distance between *A* and *B* in the leaf stalk, plus the *latent period* of the contracting pulvinus. Subtracting this from the total observed time, i. e., three tenths of a second, we get the actual time required by the impulse to travel through a given length of leaf stalk. Hence the actual speed of transmission in the plant can be found.

In carrying out this idea into practice, many serious difficulties are met with. The pull exerted by the falling leaf is very slight, and on account of friction the writer remains stuck for a time against the recording surface. Continuous contact of the writer thus introduces an error due to friction. It is true that by lifting the writer off the plate we may get rid of the friction, but in that case there would be no record. The only way out of the difficulty appeared in the compromise of making intermittent instead of continuous contact. The possibility of this lay in rendering the writer tremulous. Fresh difficulties arose which were finally overcome by an invention depending on the phenomenon of resonance.

THE RESONANT RECORDER.

The principle of my resonant recorder depends on a certain phenomenon, known in music as resonance

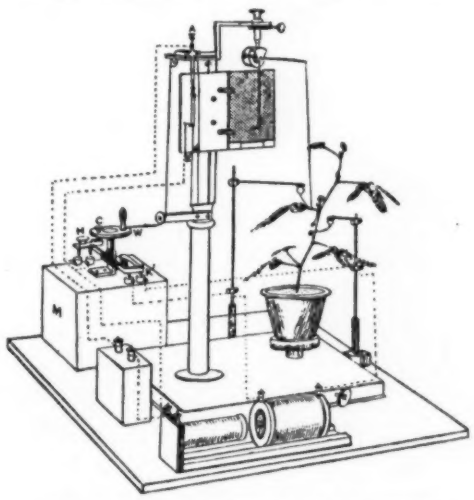


Fig. 11.—The resonant recorder and its accessories.

or sympathetic vibration. We may be so tuned as to thrill to certain notes and not to others.

If the strings of two different violins are exactly tuned, then a note sounded on one will cause the other to vibrate in sympathy. We may likewise tune the vibrating writer *V* with a reed *C*, (Fig. 9). Suppose the reed and the writer had both been tuned to vibrate

Fig. 14.—Abolition of conduction of excitation by the action of potassium cyanide. (1) Normal record. (2) Arrest of conduction after application of poison for 5 minutes. (3) Persistence of arrest even when stimulus intensity was raised fifteenfold. (4) Record of direct stimulation.

a hundred times in a second. When the reed is sounded the writer will also begin to vibrate in sympathy. In consequence of this the writer will no longer remain in continuous contact with the recording plate, but will deliver a succession of taps, a hundred times in a second. The record will therefore consist of series of dots, the distance between one dot and the next representing one hundredth part of a second. With other recorders it is possible to measure still shorter intervals. It will now be understood, how by the device of the resonant recorder we not only get rid of the error due to friction, but make the record itself measure time, as short as may be desired. The extraordinary delicacy of this instrument will be understood when it is stated that by its means it is possible to record a time interval as short as the thousandth part of the duration of a single beat of the heart.

PERCEPTION PERIOD OF THE PLANT.

The instrument has been the means of discovering various characteristics of the plant hitherto unknown. How long, for example, does it take the plant to perceive a blow and give an answering signal? As stated before the recording plate during its fall makes a short-lived electric contact at a certain part of its course, causing instantaneous excitation of the pulvinus of *Mimosa*. The complete apparatus is seen in Fig. 6. The moment of application of stimulus is marked on the recording plate by a short line. The interval between this and the answering movement in the record gives the latent period. Two such records are given in Fig. 5, which gives identical results. The space between successive dots represents intervals of a hundredth part of a second, and there are in the present case 10.9 such spaces, between the application of stimulus and the resulting response. Hence the latent period of *Mimosa* is 0.109 second. In more active specimens the latent period is as short as six one hundredth parts of a second. This is only six times the value of the latent period of the muscle of an energetic frog. A second record (Fig. 6) is given where the successive dots are at intervals of 0.005 second. As it is not difficult to estimate one fifth of the interval, it is evident that we have here a means of calculating time-intervals as short as a thousandth part of a second. A curious thing about the latent period is that while a stoutish plant gives an answer in a leisurely manner, that given by a thin one is almost hysterical in its abruptness. The perception time of the plant becomes very sluggish, under fatigue; when excessively tired it temporarily loses for the time being all power of perception: in this condition the plant requires at least half an hour's absolute rest to regain its equanimity. After describing the method of obtaining the latent period, I shall now proceed to measure the speed of the transmitted effect in the plant, which I shall in anticipation of what follows, call the excitatory or nervous impulse.

DETERMINATION OF SPEED OF NERVOUS IMPULSE IN PLANTS.

A stimulus is applied at a certain known distance, and the interval between the application of stimulus and response is found from the record. On subtracting from this the latent period of the pulvinus, we obtain the exact time taken by the nervous impulse to travel through the given distance. As relatively long intervals have to be measured, the recorder had its frequency adjusted to ten vibrations per second; hence the space between successive dots represents an interval of one tenth of a second. In Fig. 8 is given a record for determining the velocity of transmission. The two lower figures give results of successive experiments when stimulus was applied at a distance of 30 millimeters (25 millimeters is equal to 1 inch). The uppermost is the record for direct stimulation. From these it is seen that the interval between stimulus and response is 1.6 second and that the latent period is 0.1 second. Hence the true time for the excitation to travel through a distance of 30 millimeters is 1.5 seconds, or a velocity of 20 millimeters per second.

The velocity of nervous impulse in the plant is slower than those of higher, but quicker than those of lower animals. The speed of the impulse is however subject to variation under different conditions. One significant result that came out was that while a plant carefully protected under glass from outside blows looked sleek and flourishing, yet as a complete and perfect organism it proved to be a failure. Its conducting power was found atrophied or paralized. But when a succession of blows rained on this effete and bloated specimen, the internal condition of the plant improved. It became more alert and responsive, and was able to send out excitatory impulses with enhanced speed.

INFLUENCE OF TEMPERATURE ON VELOCITY.

As previously stated, a decisive experiment to discriminate between the theories of mechanical and nervous transmission, consists in the determination of the effect of temperature on the speed of transmission. Temperature has no effect on mechanical propagation, whereas a moderate variation of it profoundly affects nervous transmission. The result given in Fig. 7 is quite conclusive as regards the excitatory character of the impulse in plants. It is seen that with rising temperature, the time required for transmission through the same distance is continuously reduced. In the present case the velocity is seen to be more than doubled by a rise of temperature through 9 degrees.

The converse of this experiment is still more interesting. Stimulus was in all cases applied on the leaf-stalk at a distance of 30 millimeters from the pulvinus. The normal record (1) is first taken. After this a breadth of 10 millimeters of stalk, midway between the point of stimulation and pulvinus, is slightly cooled by application of cold water. The transmission time (2) is seen to be prolonged under moderate cooling. The selected portion of the stalk was then further cooled by fragments of ice. The record (3) shows an abolition of response, transmission of the excitatory impulse being completely arrested by excessive cold. That the absence of response was due to the abolition of conducting power, and not of motile excitability of pulvinus is seen from the fact that it gave normal response (4) under direct stimulation.

ARREST OF NERVOUS IMPULSE BY ELECTRIC BLOCK.

A very striking proof of the identity of impulses in plant and animal is furnished by the arrest of excitatory impulse under electric block. It is known that if a constant electric current be kept flowing in the nerve in an intervening tract between the point of application of stimulus and the responding muscle, then the current acts as a block to the passage of excitation. The block is instantly removed by the stoppage of the electric current. I have been able to produce precisely similar results in the plant, in which excitation could be transmitted or arrested at will. In Fig. 13 is seen a record where the impulse is seen arrested under electric block at *BB;* but on the removal of the block, excitatory impulse is found to be transmitted causing responsive fall of the leaf.

BLOCK OF CONDUCTION BY THE ACTION OF POISON.

I have also succeeded in arresting conduction of excitation in plants by local application of posionous drugs. The defect of Pfeffer's experiment lay in his attempt to arrest the impulse by the application of a volatile anæsthetic like chloroform on the surface of a thick stem. The chloroform escapes in the form of vapor; the access of the solution under these conditions to the interior of the tissue by absorption, can only be slight, and therefore ineffective in arresting the excitatory impulse. It occurred to me that the physiological block induced by a drug could be rendered more effective in two different ways. First by the selection for the purpose of the experiment a thin leaf-stalk instead of a thick stem, so that the access of the solution to the interior became less difficult. In the second place by the employment of strong non-volatile toxic agents like solutions of copper sulphate or of potassium cyanide. The choice of a strong poison was deemed advisable, because the absorption of even a small quantity might in such a case prove effective in abolishing the conducting power. My anticipations were fully justified. By the application of copper sulphate, the conducting power was found arrested in the course of twenty minutes. But the more deadly cyanide solution abolished the conducting power in a period as short as five minutes. That the local application of the poison on the leaf-stalk had only arrested the conducting power without abolishing the contractility of the distant pulvinus, is seen from the fact that the leaf gave the normal response to direct stimulation.

THE PLANT—A COMPLEX UNITY.

The plant has thus been made to exhibit many of the activities which we have been accustomed to associate only with animal life. In the one case, as in the other, stimulus of any kind will induce a responsive thrill. There are rhythmic tissues in the plant which like those in the animal go on throbbing ceaselessly. These spontaneous pulsations in the one case as in the other, are affected by various drugs in an identical manner. And in the one case as in the other, the tremor of excitation is transmitted with a definite and measured speed from point to point along fiber-like channels. We have now before our mind's eye the whole organism of the moving, perceiving and responding plant—a complex unity and not a congeries of unrelated parts. The barriers which separated kindred phenomena are thus thrown down, and the animal and the plant are seen to be a multiform unity in a single ocean of being.

The Establishment of a Race of White Canaries*

A Study in Mendelian Inheritance

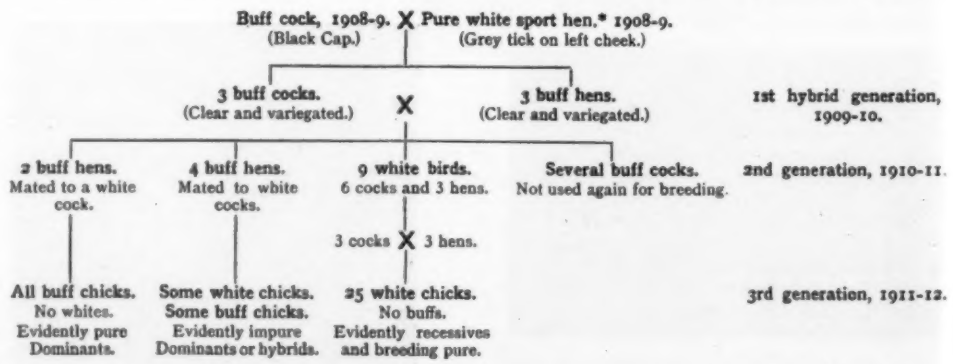
By Maud S. Martin

DURING the season of 1908 and 1909 a pure white hen canary (having a gray tick on the left cheek) was hatched in Martinborough, Wellington, New Zealand, being a sport from ordinary buff parents, its mother being a buff hen with a black cap, and its father a buff cock with a green crest and green wing mark. In the same nest as the white sport were three other birds, all buffs, more or less marked with green. All the birds in this aviary were very much in-bred, and many of them were very pale in color, being a creamy white in the nest feathers, but moulting brighter. One very pale cock bird (with a gray tick on the left cheek) was mate to most of the hens, both young and old.

The parent birds escaped after rearing their brood.

The white sport hen was bred by Miss Lee, of Martinborough, and I purchased it from her, as I intended, if possible, to produce from it a race of white canaries breeding true to color. To attain this end I determined to experiment on Mendel's lines and bought as a mate for the white sport a buff cock, quite unrelated to her. From the mating of this pair in 1909 and 1910, I reared three buff cocks and three buff hens (see Figures 1 and 2). No "whites" appeared, which is, of course, what I expected. The white sport hen died before the next season, so I was unable to use her again, and was left with her young ones (three buff cocks and three buff hens) to carry on the experiment. Some of them were clear and some variegated.

These three buff cocks and three buff hens I mated together in 1910 and 1911 and obtained from them forty-eight buff chicks and eighteen white ones, proving their hybrid character (see Figures 1 and 3). Nine of the "whites" were reared, six cocks and three hens, and I kept five buff hens to breed with the following


Buff cock, 1908-9. (Black Cap.)
X
Pure white sport hen.* 1908-9. (Grey tick on left cheek.)
3 buff cocks. (Clear and variegated.)
X
3 buff hens. (Clear and variegated.)
1st hybrid generation, 1909-10.
2 buff hens. Mated to a white cock.
4 buff hens. Mated to white cocks.
9 white birds. 6 cocks and 3 hens.
Several buff cocks. Not used again for breeding.
2nd generation, 1910-11.
3 cocks X 3 hens.
All buff chicks. No whites. Evidently pure Dominants.
Some white chicks. Some buff chicks. Evidently impure Dominants or hybrids.
25 white chicks. No buffs. Evidently recessives and breeding pure.
3rd generation, 1911-12.

* NOTE.—The white sport was bred from ordinary variegated buff parents and very much in-bred. One pale buff cock, in particular, appeared several times as father in previous generations, the white hen being his granddaughter on both sides.

Fig. 1.

* Reproduced from *Knowledge*.

year. The buff cocks I did not use for breeding as I had not white hens enough to spare to test them with to see if they carried white blood. Also there would certainly be some dominants in them and I did not want to increase my breeding operations or to multiply the buff birds, for which reason I did not use the buff hybrid cocks of the first generation again, but used only the white cocks as mates for all the hens the following year.

The three buff hens of 1909 and 1910 (first hybrid generation) I mated in 1911 and 1912 to their sons the white cocks of 1910 and 1911 (second generation) and from them I obtained fourteen buff chicks and twenty-six white chicks (see Fig. 4).

The three white hens (1910 and 1911, second generation) I mated to white cocks (1910 and 1911, second generation) in 1911 and 1912, and from them I obtained twenty-five white chicks, no buff ones appearing in the nests at all, apparently proving their recessive character (see Figure 5). The six buff hens (1910 and 1911, second generation) I mated to white cocks (1910 and 1911, second generation) in 1911 and 1912. Two

RESULTS OF MATING 3 BUFF COCKS AND 3 BUFF HENS, 1909–10.

1st Hybrid Generation from Buff Cock and White Hen Sport, the Hens being the Sisters of the Cocks.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 6 broods.	3 3 2 4 3 3	0 1 1 1 1 0	
II. 6 broods.	4 4 1 4 3 3	1 0 1 1 1 2	
III. 7 broods.	1 3 4 1 2 0 0	0 1 0 3 1 1 2	
	48	18	2nd Generation from White Hen, 1910–11.

Fig. 3.

RESULTS OF MATING 2 BUFF HENS, 1910–11, AND WHITE COCKS, 1910–11, ALL SECOND GENERATION FROM WHITE HEN SPORT.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 4 broods.	3 4 2 3	0 0 0 0	Apparently these two hens were dominants, as they gave no white chicks in any nest.
II. 3 broods.	3 3 4	0 0 0	
	22	0	3rd Generation, 1911–12.

Fig. 6.

of them gave me only buff birds, no white ones appearing in the nests at all, which looked as though they were dominants (see Figure 6), the other four hens having sixteen buff chicks and twenty-seven white ones, evidently being hybrids, or impure dominants (see Fig. 7).

The details of each nest are made out in the accompanying tables. The eggs were carefully numbered and the young had numbered rings on their legs, so that there should be no mistaking the birds belonging to each pair.

The white chickens are easily distinguished directly they are hatched, as their skin is a pale bright pink, quite unlike the ordinary yellow appearance of a common hatching. Very often (but not always) the hybrid chicks have a pinkish-yellowish body when first hatched, but this soon turns yellow, and is never the bright light pink of the white chick. Also the hybrid chicks are generally (but not always) very pale in the nest feathers, quite a creamy white, but becoming brighter yellow later, although many remain very pale, but not all of them. It was on account of these two peculiarities of the hybrid birds that I mated the two buff hens (see Figure 8) to the white cocks, as I suspected that they would have young white ones, which they both did have. Hen I (1907 and 1908) I hatched in my own aviary, and she was almost white in the nest feathers and always continued very pale, and when mated to a goldfinch gave me pied mules. Hen II (1909 and

RESULTS OF MATING BUFF COCK, 1908–9, TO WHITE SPORT HEN, 1908–9.

Unrelated.

Pair.	Buff Chicks.	White Chicks.	Remarks.
Original. 4 broods.	2 2 3 2	0 0 0 0	The young ones in the third nest died.
	9 six survived.		1st Hybrid Generation, 1909–10.

Fig. 2.

RESULTS OF MATING 3 BUFF HENS, 1909–10, OF THE 1ST HYBRID GENERATION TO 3 WHITE COCKS OF THE 2ND GENERATION, THE HENS BEING THE MOTHERS OF THE COCKS.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 5 broods.	2 1 0 0 2	2 2 3 1 0	
II. 5 broods.	1 0 4 0 1	1 4 2 0 3	
III. 4 broods.	0 0 2 1	3 1 1 3	
	14	26	

Fig. 4.

RESULTS OF MATING 4 BUFF HENS, 1910–11, AND WHITE COCKS, 1910–11, ALL SECOND GENERATION FROM WHITE HEN SPORT EXCEPT THE HEN IN PAIR IV.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 3 broods.	0 3 2	3 2 2	Apparently these 4 hens were impure dominants, as they gave white chicks as well as buffs. The hen of the 4th pair was descended from the White Sport Hen on the father's side only, though related on the mother's.
II. 3 broods.	3 1 1	0 3 1	
III. 3 broods.	1 2 1	3 2 2	
IV. 3 broods.	0 1 1	4 2 3	
	16	27	3rd Generation, 1911–12.

Fig. 7.

RESULTS OF MATING JONQUE CINNAMON HEN AND WHITE COCK.

Unrelated.

Pair.	Description of young birds.	
I. 3 broods.	1 jonque green hen. 1 buff green cock. 1 clear buff hen.	No whites appeared, as was expected. The buffs are exceptionally pale coloured.
	1 buff green hen. 2 clear buff cocks. 1 yellow bird (died young).	
	3 green birds. 2 yellow birds (died young).	

Fig. 9.

1910) had peculiarly pinkish-yellowish chicks, so I suspected her too of carrying white blood, and in 1910 and 1911 mated her to a first hybrid generation buff cock, from which mating I got only one pale hen. The following year (1911 and 1912) I mated both mother and daughter to a white cock (1910 and 1911, second generation) and got white chicks from both of them. The daughter is the hen in Pair IV in Fig. 7.

I have other pale hens (older) related to the white sport (but not descended from her), as Miss Lee and I have for many years exchanged birds from our aviaries. These hens I intend this year to mate with white cocks, to prove if they are hybrids or not, as I fancy some of them carry white blood too. (Miss Lee, I think, must have many birds capable of producing white chicks, as her birds are mostly very pale, but she does not, I think, care to experiment systematically.)

All my birds (and also Miss Lee's) are buff, being bred from buff cocks and buff hens, except the progeny from the jonque cinnamon hen (see Figure 9) from which bird I have one jonque green hen, to be mated this year (with the other young of the cinnamon hen) with a white cock. This cinnamon I bought, and it is quite unrelated to my other stock. The clear buff hen in the cinnamon's first nest was extremely pale (quite white in patches) in its nest feathers, and has remained extremely pale, as have also the two

RESULTS OF MATING 3 WHITE COCKS AND 3 WHITE HENS, 1910–11, 2ND GENERATION FROM WHITE HEN.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 3 broods.	0 0 0	2 4 4	The first hen died half-way through the season. All the birds were white, as was expected and hoped for. It appears that white colouration is recessive according to Mendel's law.
II. 4 broods.	0 0 0 0	0 5 2 0	
III. 4 broods.	0 0 0 0	3 2 0 3	
	0	25	3rd Generation from White Hen.

Fig. 5.

RESULTS OF MATING 2 BUFF HENS (CLOSELY RELATED TO THE WHITE SPORT, ONE BEING ONE YEAR OLDER AND ONE BEING ONE YEAR YOUNGER, BUT NOT DIRECTLY DESCENDED FROM HER, BOTH HAVING ANCESTORS IN COMMON AND BOTH BEING DESCENDED FROM THE PALE BUFF COCK MENTIONED IN THE NOTE (TABLE 1), TO WHITE COCKS, 1910–11.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 2 broods.	0 0	1 1	Other nests of the hen in Pair I came to nothing. The hen in Pair II was the mother by a buff cock (1st Hybrid Generation) of the hen in Pair IV. in Table 7.
II. 3 broods.	3 1 3	2 1 1	
	7	6	

NOTE.—I mated these two buff hens to white cocks as I knew they were both related to the White Sport, and I thought, for several reasons, that they might carry white blood. Evidently, the white blood must have been in the strain several years before the White Sport was hatched. No more whites have appeared in that aviary, but they have not tried for them systematically. I have other old hens related to the White Sport, which I am mating this year to White Cocks, to see if perhaps they will prove to be hybrid from their breeding results.

Fig. 8.

young clear buff cocks in her second nest; they are quite as pale as any of my buff birds bred from clear buff hens and white cocks, and much paler than many of them. This is remarkable as the basis of cinnamon coloring is green.

All my white birds have black eyes, not pink as one might imagine they would have, and they are very strong and hardy, being bred and reared out of doors and living in an open out-door aviary all the year round.

In their case their white plumage does not seem to make them delicate.

Altogether, I think the experiment has been most successful, as I have established my race of white canaries breeding true to color, and apparently the colors yellow and white obey the Mendelian laws, producing dominants, impure dominants (or hybrids) and recessives.

Sawmill waste of Douglas fir, of which an enormous quantity is found in the western forests, is being used to make paper pulp by a mill at Marshfield, Oregon.

Miss George showing children how to spell and space words made from cardboard letters. Two cases contain in various compartments all the letters cut in script. Five complete alphabets are used.

Plane geometrical insets in wood are used in the education of the stereognostic sense. The insets are mixed up and the child puts them into place by sight and by touch.

What is the Montessori Method?

Application of Science to Education

By Sidonie Matzner Gruenberg

THE application of scientific methods to problems of education has been going on for a long time, but none in this field has heretofore appealed to the popular imagination as has Dr. Maria Montessori. This woman, trained as a physician and experienced in methods of scientific research, made her opportunity to observe feeble-minded children under medical treatment her point of departure in educational theory. In the nineties there was a tendency among those studying mental defectives to resort to special gymnastics for the treatment of these cases. Dr. Montessori at that time emphasized the importance of pedagogical rather than medical treatment for such children. In 1898 she presented her views at the Pedagogical Congress at Turin and immediately received the recognition of the leading educators. Shortly afterward she was invited to address the teachers of Rome on her ideas on training feeble-minded children, and there was then established an all-day school for children who were considered hopelessly deficient, which was placed in her charge.

During all this time Madame Montessori felt that the methods used with feeble-minded children were not in any way such as to exclude their application to *normal* children, and there grew upon her the conviction that the methods in ordinary use were far from being suitable for *any* children.

She therefore undertook a thorough study of pedagogy in all its branches with a view to preparing herself for a systematic test of her theories. In the works of Seguin and Itard, Dr. Montessori found material for developing her ideas of reforming the schools and stimulus to further effort.

There is nothing distinctive about Dr. Montessori's views that the development of the child must come through his spontaneous expressions and activities. All the pedagogues, beginning with Rousseau, demanded liberty for the child. However, on the part of the educators of the past this desire for liberty was a vague intuition; they knew it was essential to normal development, yet they had no means of establishing it when they were concerned with groups. Dr. Montessori, making use of the results of the modern psychology and pedagogy, has worked out a method which is remarkably effective with young children.

Inasmuch as we have not known how to keep groups of children occupied and happy and free, we have felt compelled to suppress their initiative, organize them into inactive classes and pour dismal knowledge into them. The result has been that the children "confounded immobility with goodness and activity with evil." "The liberty of the child," says Dr. Montessori, "has as its *limit* the collective interest; as its *form*, what we universally consider good breeding. We must therefore check in the child whatever offends or annoys others, or whatever tends toward rough and ill-bred acts. But all the rest—every manifestation having a useful scope—whatever it be, and under whatever form it expresses itself, must not only be permitted, but must be observed by the teacher."

The essential feature of the method, so far as the teacher is concerned, is that the children in action are to be studied by the teacher in the scientific spirit. The teacher must not treat the class as a group of passive beings to be *taught*, but must have toward each individual the attitude of the experimental biologist. She must discover how the child reacts to different kinds of stimuli, what he can do, and the effects upon him of various changes in his environment. This ideal of the function of the teacher is unique. She considers "a room in which all the children move about usefully, intelligently and voluntarily, without committing any rough or rude act, a classroom very well disciplined indeed."

In order to carry out these ideas there are needed a school and materials. The first opportunity Dr. Montessori had to try out her plans was afforded by the remodeling of a group of tenements in Rome. The plans for these tenements included a room in which the children of the tenants could be gathered during the day while their parents were away at work. The play and work of these children was to be carried on under the direction of a teacher, who was to have her own residence in one of the apartments. The "House of Childhood" has a twofold significance: "The social importance which it assumes through its peculiarity of being a school within the house, and its purely pedagogic importance gained through its methods."

It is impossible here to dwell upon the full social significance of the houses of childhood, although it is well worth thoughtful consideration. On the pedagogical side Dr. Montessori has made many interesting experiments, but several points are of special interest. First of these, for social as well as for pedagogical reasons, is the fact that she admits to her school children much younger than have usually been placed under systematic school work, even in Kindergartens. She and the teachers trained by her have successfully managed groups of children from two and a half to six years of age without placing them under formal restrictions. Each child is free to pursue the activity that interests him most for the time being, and is free to change as frequently as he may wish. The good order maintained in the class without resort to any form of regimentation is due very largely to the fact that provision is made for interesting activities with special apparatus. This material is designed in order to meet the child's need for certain manipulations and activities and is so arranged as to give a thorough training of all the senses. For the most part this material is self-checking. For example, there are blocks of wood with holes of different sizes and a series of cylinders with metal knobs to fit these holes; the child tries to place each cylin-

To teach the child how to discriminate objects according to thickness, height and size, geometrical solids are employed. In this picture Miss George is shown teaching children to determine by the sense of touch the shape of various objects.

A glimpse of Miss Anne E. George's school conducted on the Montessori principle, at Tarrytown, N. Y.

At this school, each child is permitted to do whatever happens to appeal to her. No restraint is imposed.

der in the appropriate hole; if he makes one mistake the set cannot be completed. With this apparatus the child working by himself learns to discriminate proportions. A large number of insets of various forms and sizes enables the child to learn through his own activity to discriminate geometrical figures and dimensions. Special material is used for exercising each of the senses, and Dr. Montessori lays particular stress on the training of the sense of touch, which she feels has been too much neglected.

Her method of teaching writing is tremendously suggestive, and grew out of the difficulties encountered by an idiotic girl trying to learn darning. Dr. Montessori observed that this feeble-minded girl had no control of the needle, and gave her the paper weaving mats designed by Froebel. The girl learned to work with the paper strips, and having acquired the necessary movement for darning, was able to do it with a needle when this kind of work was again presented to her. From this experience Madame Montessori concluded that before learning a difficult art, such as sewing or writing, the child should be prepared by suitable exercises. She then analyzed the process of writing and found two essentially distinct sets of activities, namely, the manipulation of the tool and the tracing of the outlines. Her children learn to handle the writing instrument by tracing outlines around the geometrical insets with a colored crayon selected by themselves, and then filling in the empty space, all the time holding the pencil as in writing. They thus acquire control of the instrument without actually writing. For acquiring "the muscular memory of the movements necessary for writing," and at the same time a visual knowledge of the forms, she gives them letters cut out of sand paper and mounted on card board; the children pass their fingers over these outlines in the same direction in which the letters are formed in writing.

"The average time that elapses between the first trial of the preparatory exercises and the first written word is, for children of four years, from a month to a month and a half. With children of five years, the period is much shorter, being about a month. But one of our pupils learned to use in writing all the letters of the alphabet in twenty days. Children of four years, after they have been in school for two months and a half, can write any word from dictation, and can pass to writing with ink in a note book. Our little ones are generally experts after three months' time, and those who have written for six months may be compared to children in the third elementary. Indeed, writing is one of the easiest and most delightful of all the conquests made by the child."

Contrary to common usage in school I [illegible] taught the children to write before te[illegible] read. Having done this, and dealing [illegible] a strictly phonetic language, teaching the children to read did not present many difficulties.

It is no easy matter to compare the work done by Madame Montessori's classes with that made familiar to us in our schools. Due to the fact that she teaches reading and writing we compare her work with that of the primary grades, and there indeed the contrast is very great—no desks, no restraint, no formal lessons. On the other hand, on account of the ages of the children we are tempted to compare it with the Kindergarten; here the contrast is not so great, the chief difference being in the attitude of the teacher. In the Kindergarten, the great variety of the material makes it necessary for the teacher to give much of her time to looking after this instead of to observing the children. In

1. By means of a series of blocks, decreasing in height and width, a child can exercise itself for perception of differences and dimension. 2. By means of a set of duplicate color boxes the child acquires a most exquisite appreciation and knowledge of colors. There are eight colors, each presented in a series of eight shades. A great variety of games is made possible by these two boxes. 3. The "Long Stair" is the foundation for the introduction of arithmetic. A number of rods, bearing alternating colors, are mixed. The teacher first constructs the stair, calling the child's attention to the colors. Then the child is permitted to build the stair alone. 4. The child on the left is painting with water colors. No restrictions are placed upon her. The other children are using the lacing and buttoning frames, for among the first educational gymnastics used in the Montessori method are exercises for the development of co-ordinated movements of the fingers. Thus the child is prepared for the practical exercises of dressing and undressing itself.

the Montessori schools the teacher is comparatively free and the material is handled by the children. The activities with the Montessori material are closely related to some of the activities more or less directly useful, and in a very short time the children become independent and are able to help themselves and one another. In the Kindergarten, on the other hand, every visitor must be impressed with the fact that in spite of the marvelous dexterity of the children in manipulating the regular material, they are absolutely helpless when it comes to dressing themselves.

It is hardly to be expected that any system of education can be built up by one person and adopted as complete in itself, although enthusiasts will naturally attempt to apply the Montessori methods as sufficient in themselves. Those working with these materials will soon be able to determine whether they are not too rigid and whether the self-checking feature does not interfere with the play of the child's imagination and with the opportunity for creative work on the part of the children. It is possible that material will be devised to embody all the good features of the Montessori idea and still be capable of being put together in more than one way.

Educators are seriously studying this method and there can be no doubt that both our Kindergartens and our primary grades will be greatly modified as a result of Dr. Montessori's work, and that the gap between these two stages of the child's education will be bridged thereby. As to the application of her methods in the higher grades, we shall have to await the results of the work Dr. Montessori is now carrying on.

It is surprising that a woman of such thorough training and one who uses the scientific method as a basis for all of her work should lapse into the antiquated notions about diet and nutrition exposed in parts of her book. Thus she speaks of "nerve feeding substances" years after even the U. S. courts had found out that there are no special brain or nerve foods. Again she refers to sugar as a food for "building plastic tissue," and she recommends garlic and rue because they "disinfect the intestines and the lungs."

The translation of the Montessori book by Miss Anne E. George, which has just been published, is well worth thoughtful reading by all interested in the broader problems of education as well as by those engaged in the technical work of teaching. The chapter on discipline will be a revelation to many who hold traditional ideas on the meaning of education.

Eye-Preserving Glass for Spectacles*

By Sir William Crookes

SINCE March, 1909, in connection with the Glass Workers' Cataract Committee of the Royal Society, I have been experimenting on the effect of adding various metallic oxides to the constituents of glass in order to cut off the invisible rays at the infra-red end of the spectrum, and thus to prepare a glass which will cut off those rays from highly heated molten glass which damage the eyes of workmen, without obscuring too much light or materially affecting the colors of objects seen through the glass when fashioned into spectacles.

Single metals were at first tried in varying quantities to see if from the color and properties communicated to the glass they were worth further examination. Each specimen is cut and polished into a plate 2 millimeters thick. The plate so prepared is first put into the radiometer balance to find the percentage of heat cut off. It is then tested in the spectrum apparatus to ascertain the upper limit of transmission of the ultra-violet rays; next it is tested in Chapman Jones's opacity meter to estimate the percentage of luminous rays transmitted, and finally the color is registered in a Lovibond's tintometer.

The following elements were selected as likely to be worthy of further experimentation by combining the metals, two, three, or four at a time in one glass so as to enable the advantages of one to make up for the shortcomings of another: Cerium, chromium, cobalt, copper, iron, lead, manganese, neodymium, nickel, praseodymium, and uranium.

While bearing in mind that the chief object of this research is to find a glass that will cut off as much as possible of the heat radiation, I have also attacked the problem from the ultra-violet and the transparency points of view. Taking each of these desiderata by itself, I have succeeded in preparing glasses which cut more than 90 per cent of heat radiation, which are opaque to the invisible ultra-violet rays, and are sufficiently free from color to be capable of use as spectacles. But I have not been able to combine in one specimen of glass these three desiderata in the highest degree. The ideal glass which will transmit all the colors of the spectrum, cutting off the invisible rays at each end, is still to be discovered.

So far as transparency, however, is concerned, it will not be an unmixed advantage for the sought-for glass to be quite clear and colorless. The glare of a strong light, on white cliffs, expanses of snow, electric light, etc., is known to be injurious to the eye, and therefore a tinted glass combining good observation to the heat radiation and ultra-violet rays is the best to aim for.

For ordinary use, when no special protection against heat radiation is needed, the choice will depend on whether the ultra-violet or the luminous rays are most to be suppressed, or whether the two together are to be toned down. Ordinarily the visible spectrum is assumed to end at the Fraunhofer line *K*, λ3933, but light can easily be distinguished some distance beyond by the naked eye. It may therefore be considered that the ultra-violet rays which are to be cut off on account of their possible injurious action are those of shorter wave-lengths than, say, λ3700. Many glasses have been prepared for this purpose, all of which are opaque to rays shorter than λ3700. The colors are pale green, yellow, and neutral; they transmit ample light so that a choice of tints is available to suit individual taste.

Glasses which are restful to the eyes in the glare of the sun on chalk cliffs, expanses of snow, or reflected from the sea, of yellow, green, and neutral tints, have also been prepared which have the advantage of cutting off practically all the ultra-violet rays and also a considerable amount of the heat radiation.

* Summary in *Nature* of a paper read before the Royal Society.

Man, Monkey and Their Parasites

THE so-called specific immunity reactions which have been so extensively investigated in recent years have emphasized some unusual relationships among animal species. These have expressed themselves, for example, in the precipitin and hemolysin reactions. The serum of an animal immunized against human blood gives also a precipitate in the serum of the anthropoid apes. Similarly the hemolysins specifically developed to make human blood-corpuscles act on those of the man-like apes. The reaction at once ceases, however, in the case of the ordinary monkeys.

A recent writer remarks that embryology, paleontology and comparative anatomy may have taught the same general facts, but it comes as somewhat of a shock to many to realize that man's kinship to the monkey goes so far as a "blood relationship." Few persons are as yet aware of the fact that this relationship of man by no means applies to all of the monkey tribe, but only to that group including such examples as the chimpanzee, orang, gorilla and gibbon, and not to the more common monkeys of the *Macacus* type. This subtle distinction shown in the various serum reactions is of unusual scientific interest. V. L. Kellogg, entomologist of Leland Stanford Junior University, has furnished a new and somewhat startling kind of evidence of the relationship of man to the anthropoid group of apes in distinction from others of the monkey tribe. It is based on the contention that the host distribution of the wingless, permanent skin parasites (ectoparasites) of the higher animals, including birds and mammals, is governed more by the genetic relationships of the hosts than by geographic range or any other environmental condition.[1] If this is correct the kinds of permanent ectoparasites found on individuals will indicate in some measure the genetic relationships of the hosts.

According to Kellogg[2] the wingless, permanent ectoparasites of birds and mammals are of two groups, namely, the biting lice, *Mallophaga*, feeding on the feathers and hair, and the sucking lice, *Anoplura*, feeding on blood. Certain mites (*Acarina*) may perhaps also be assigned to this category of permanent wingless parasites, but the fleas cannot be, for they hop on and off their host, and all their immature life is non-parasitic and wholly apart from their future hosts. The *Mallophaga*, of which nearly two thousand species are now known, occur chiefly on birds, while the *Anoplura*, of which less than a hundred are known so far, are confined to mammals. No biting lice have been found on man or on any anthropoid.

Sucking lice of species representing two genera, *Pediculus* and *Phthirius*, occur on man. Representatives likewise have been found on the anthropoid gibbons and chimpanzee. The other tailed monkeys which, in contrast with the man-like apes, are shown by the "blood relationship" tests to be unrelated to man, harbor parasites of entirely distinct genera. The resemblance of man to his simian cousins crops out in this most unexpected fashion.

How these remarkable affinities of host and parasite are preserved is not easy to explain. The California entomologist responsible for the facts recited states that he has often become, in the course of collection, the temporary host of various bird- and mammal-infesting biting lice, but these parasites all seemed as anxious to escape as he was to have them do so. And they did escape; or, if they did not, they died in a few hours. There is, indeed, an extraordinarily exact fitting of parasite to host in the case of biting and sucking lice. It is hard to understand—to quote Kellogg—of just what details this fitting consists, beyond the more obvious structural and morphologic differentiations. The essential fitting is far more subtle. It is a fitting to the host's physiology as well as to its epidermal structures. —*Journal American Medical Association.*

[1] Kellogg, V. L.: Distribution and Species-Forming of Ectoparasites, *Am. Naturalist*, 1913, xlii, 129.

[2] Kellogg, V. L.: Ectoparasites of the Monkeys, Apes and Man, *Science*, 1913, xxxviii, 601.

The Temperature of Arc Lamps

M. Lummer has just concluded a series of experiments to see if really carbon boils like water; that is to say, if the temperature of ebullition increases when the pressure augments. According to M. Violle, the temperature of the electric arc, in the crater, is the temperature of the volatilization of carbon. The temperature of the crater of the positive carbon may be estimated at 4,000 degrees, that of the negative being from 600 degrees to 700 degrees lower. If the temperature depends upon the pressure it would be possible by increasing this latter to augment the temperature of the arc far beyond the present temperatures. The quantity of light produced would also be greater. The experiments undertaken by M. Lummer seem to prove that it will be possible to arrive at a greater luminous intensity.—*Chemical News.*

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